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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See half-page Advertisement, last and next week.

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See Full Page Advt., page 63, Oct. 19.

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See Advertisement page 28, Oct. 26. 3492

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See half-page Advertisement page 78, Nov. 2.

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MUNICIPAL COUNCIL OF JOHANNESBURG.

CONTRACT 926.—The SUPPLY and ERECTION of EXTENSIONS to REFRIGERATING PLANT and Fitting-up of Refrigerating Chambers at the Municipal Abattoir, Newtown, Johannesburg, South Africa.

Sealed Tenders, endorsed with Contract No., will be received by the Town Clerk, Tender Box, Municipal Offices, Johannesburg, not later than Noon, 18th February, 1918, for the above.
Drawings and documents may be viewed at the Council's London Agents, Messrs. R. W. CARLING and Co., St. Dunstan's Buildings, St. Dunstan's Hill, London, E.C., and copies obtained on payment of £2 2s. The lowest or any Tender will not necessarily be accepted.

G. S. BURT ANDREWS,
Johannesburg, Town Engineer.
14th September, 1917. J 354

COUNTY BOROUGH OF SALFORD.

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L. C. EVANS,
Town Clerk.

APPOINTMENTS OPEN.

COVENTRY EDUCATION COMMITTEE.

Applications are Invited for the POST of PRINCIPAL of the Municipal Technical School.
Commencing salary £600 per annum.
Particulars of the Appointment and Forms of Application, which must be returned on or before 1st December, 1917, may be obtained from
FREDK. HORNER,
Education Department, Secretary,
Council House, Coventry.
6th November, 1917. J 358

CITY OF LIVERPOOL.

EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL, WALTON AND KIRKDALE TECHNICAL INSTITUTE, CARISBROOKE ROAD.

A Head Master is Required for the Junior Technical School to act also as Superintendent of the Evening Technical Classes held in the same building. The person appointed will be required to devote the whole of his time to the service of the Committee. He must hold good mathematical and scientific or technological qualifications. Commencing salary at the rate of £300 per annum; the engagement will be determinable by three months' notice.—Applications, giving particulars of age, educational training, teaching and workshop experience, etc., with references and copies of recent testimonials, to be sent to the DIRECTOR OF EDUCATION, Education Offices, Sir Thomas Street, Liverpool, not later than Thursday, 22nd November, 1917. J 345

R. R. PICKMERE,
Town Clerk.

KENT EDUCATION COMMITTEE.

DAY JUNIOR TECHNICAL SCHOOL, MAIDSTONE.

Assistant Master Required. Graduate in Engineering with workshop experience preferred. Initial salary £300 a year.
Application forms may be obtained from R. W. H. ABBOTT, Esq., Technical Institute, Maidstone, and should be returned not later than 17th November, 1917. J 330

FRAS. W. CROOK,
November, 1917. Secretary.

SOUTH WALES AND MONMOUTHSHIRE SCHOOL OF MINES.

Wanted for the duration of the War a Senior LECTURER in mechanical engineering and mathematics, to act temporarily as head of the mechanical engineering department.
Applicants must have had workshop experience and a knowledge of mining engineering practice, and must be capable of conducting testing work.
Also Senior LECTURER in chemistry and physics, to act temporarily as head of the chemistry department.
Applicants must have had works experience and a knowledge of mining chemical practice, and must be capable of conducting testing work.
Only candidates ineligible for military service need apply.
Salary according to qualifications and experience.
For further particulars apply to:—
THE PRINCIPAL, J 284
Treforest,
South Wales.

Works Manager's Assistant WANTED, for Controlled Establishment, North-West London District. Good opening and permanent position for a man possessing good all-round engineering knowledge. Applicants should have received a thorough training in systematic and efficient factory organization. No persons more than 10 miles away or engaged on Government work need apply.—Write, stating qualifications and salary, to J 270, Offices of ENGINEERING.

Wanted, for Controlled Establishment, North-West London District, ASSISTANT WORKS MANAGER or SUPERINTENDENT, for taking entire control of about 1000 workpeople, male and female. The position will be a permanent one, and offers considerable scope for an engineer who is a systematic and capable organiser and has had experience in a somewhat similar position. No persons more than 10 miles away or engaged on Government work need apply.—Write, stating qualifications and salary required, to J 269, Offices of ENGINEERING.

Chemist, First-class, Required for large manufacturing concern. Must be well up in metallurgy (especially steels) and photo-micrography. No one already engaged on Government work or residing more than ten miles away need apply.—Address, giving details of experience, salary required, &c., J 347, Offices of ENGINEERING.

Required, in Government Factory, METALLURGICAL CHEMIST, for analysis of ferrous and non-ferrous alloys. Previous experience preferable but not essential. Men already on Government work need not apply.—Apply, giving full details of experience and salary required, to the nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 3865. J 160

Checker Wanted, for Drawing Office engaged on Aircraft manufacture. A thoroughly reliable man, with good practical and technical experience for checking Jig, Tool and General Engineering Drawings. Good salary and prospects to a really first-class man. No one residing more than 10 miles away or already employed on Government work will be engaged.—Address, J 278, Offices of ENGINEERING.

Chief Inspector Required by Government Controlled Establishment in Eastern Counties for examining finished metal parts for aeroplanes. To be directly responsible to the Management. Must be man of good type with first-class experience, who can inspire confidence, and only persons with such qualifications need apply. No one already on Government work can be engaged. Applications to be made through nearest EMPLOYMENT EXCHANGE, stating age, experience and salary desired. Please mention this Journal and J 320.

Inspectors Required for Government Controlled Establishment, situated in the Eastern Counties. Must be able to work to drawings and be used to micrometer and vernier. Only first-class men need apply. Applicants must state age, experience, and salary required to nearest EMPLOYMENT EXCHANGE, mentioning this paper and J 319. No one already on Government work can be engaged.

Wanted, Assistant Metallurgical CHEMISTS, experienced in the analysis of steel, &c., including carbon by combustion. To work eight hour shifts. State age, experience, and salary required. No one already employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 338.

Mechanical Engineer, Good Technical Training, to Supervise drawing office and technical training. Experience in elevators and conveyors preferred. Important Government work with fixed after-war position. Silver badged men preferred, subject to experience. No one resident more than 10 miles away or already on Government work will be engaged. Replies, which will be treated in strict confidence, should state age, full experience with details of past work and salary expected to BOX 409, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, London, E.C. 4. J 309

Steelworks Engineer Required accustomed to extension and maintenance of Melting Furnaces (Bessemer, Siemens, and Electric), Rolling Mills, Forges, &c.—Address, W.M., BROWN, BAYLEY'S STEEL WORKS, LTD., Sheffield. J 300

Wanted, Prime Cost Clerk for Engineering Works, with good technical knowledge and varied experience. State full particulars and salary required. Immediate engagement. No one already engaged on Government work, or residing more than ten miles away, need apply.—Address, J 279, Offices of ENGINEERING.

Wanted, Engineers Experienced in estimating cost prices of machining work, and fixing piecework prices. No person resident more than ten miles away or already engaged on Government work will be engaged.—Apply, A. D. T. C., Room 36, Hotel Metropole, London. J 325

Wanted, a First-class Stores ORGANIZER. Must be good disciplinarian and capable of taking charge of a large store. Good salary to the right man. When answering send fullest particulars of your experience. No one engaged on Government work will be employed.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 376.

Buyer Wanted for New Aero- plane Factory in the North. Must have sound previous experience in similar capacity, and thorough knowledge of markets and materials.—Applications, with full details of qualifications, salary required, when at liberty, &c., should be made to nearest EMPLOYMENT EXCHANGE, quoting this Journal and J 383.

Travelling Representative WANTED for Lancashire District to handle high-class machine tools and small tools. Preference will be given to those with shop experience. No person already on Government work will be engaged.—Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3963. J 360

Required, in Government Factory, for work in connection with Aeroplanes and Aeroplane Engines, several YOUNG MEN with scientific engineering training. Previous experience of aeroplanes not essential. Men already on Government work need not apply.—Send full details of experience and salary required to your nearest EMPLOYMENT EXCHANGE and quote reference number A 3859. J 169

Wanted, Technical Assistant for Power Plant Work; age about 23.—Applications, stating age, qualifications, experience and salary required, accompanied by copies of testimonials, should be addressed to J 241, Offices of ENGINEERING.

First-class Hardener Wanted, with good experience of high-speed steel, press tools and gauges. Good wages paid to man of experience. No one already on Government work can be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 322.

Energetic and Active Assis- tants REQUIRED for follow-up work in Progress Department of Aeronautical Establishment in Eastern Counties. Good wages will be paid to live and intelligent men.—Please mention this paper and J 321, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE. No one already on Government work can be engaged.

Assistant Required for Pur- chasing Office of Controlled engineering firm, Manchester district. No one already on Government work need apply.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3924 and ENGINEERING. J 239

Assistant (Departmental) REQUIRED by Engineers in London for taking in hand contracts, ordering materials and following progress. Applicants must have similar experience. State age, salary, full particulars, and when at liberty. No one residing more than ten miles away, or already on Government work, will be engaged.—Address, J 310, Offices of ENGINEERING.

Electrician Wanted, to Take Oversight of the Electrical Branch of an Engineering establishment. A man with all-round knowledge of Engineering preferred. No one residing more than ten miles away or already on Government work need apply.—Address, giving full particulars of past experience and salary required, J 383, Offices of ENGINEERING.

Designer, Motor Boats, Yachts, &c., REQUIRED for London Office, Contractors engaged on urgent Admiralty work. Good opening for capable man. State salary required, and give full particulars of experience, also enclose copies of testimonials. No one residing more than 10 miles away, or already on Government work, will be engaged. Address, J 401, Offices of ENGINEERING.

Draughtsman Wanted.—A large firm of Electrical Distribution Box Manufacturers near London REQUIRE the services of a DRAUGHTSMAN as Inspector of their manufactured gear, &c. Must be a six o'clock man. No one residing more than ten miles away or already on Government work will be engaged.—Apply, giving references and particulars of salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 274.

Draughtsman.—Wanted, by Electrical firm near London, a DRAUGHTSMAN, preferably with knowledge of electrical distribution boxes, &c. No one residing more than 10 miles away or already on Government work will be engaged.—Apply, giving references and particulars of salary required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 275.

Draughtsmen, Two or Three Mechanical, preferably with experience of design of mills; for example, paper and similar machinery. Required by Engineers in London. State full particulars, experience, salary, and when at liberty. No one residing more than ten miles away, or already employed on Government work, need apply.—Address, J 311, Offices of ENGINEERING.

Draughtsman Required for Controlled Blast Furnaces and Rolling Mills on the North-East Coast. Men already on Government work need not apply.—Apply your nearest EMPLOYMENT EXCHANGE, stating age, experience, and salary required, quoting A. 3044 and ENGINEERING. J 326

Jig & Tool Designers Wanted. First-class Men for press tools, turret and automatic machine lay-outs for aeroplane work. No one at present engaged on Government work or residing more than ten miles away, need apply.—Address, J 278, Offices of ENGINEERING.

Required, for large Govern- ment controlled factory in the Midlands, a competent Jig and Tool DRAUGHTSMAN for Aeroplane Engine work. No person already on Government work will be engaged.—Apply, stating age, reference and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3967. J 329

Draughtsmen, with Experi- ence in coke oven plant, coal-handling machinery, and chemical or tar plants. WANTED Immediately.—Apply, stating experience, age, and salary required, to KOPPERS' COKE OVEN AND BYE PRODUCT CO., 301, Glossop Road, Sheffield. No one already employed on Government work will be engaged. J 348

First-class Tool Designers REQUIRED for West London Works. Must have had good all round experience on high-class work. Only those not already on Government work, and residing within a ten-mile radius, need apply, stating age, salary and experience.—Address, J 230, Offices of ENGINEERING.

Aeronautical Engineers, London, N.W., have VACANCIES for DRAUGHTSMEN preferably, but not necessarily with previous experience of aircraft work. Apply by letter, stating age, salary, particulars of experience and when disengaged. No one need apply who is engaged on Government work or who resides more than ten miles away.—BOX B 514, SELLS, Ltd., Fleet Street, E.C. 4. H 965

First-class Draughtsman, with Steam Crane experience, WANTED at once. No one already employed on Government work will be engaged.—Apply, giving full particulars, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 194.

Several First-class Mechanical DRAUGHTSMEN, with workshop experience and technical training, are required immediately by well-known engineering firm in London. Ordinary working hours 48½. Overtime pay and good War bonus. No one employed on Government work need apply.—Apply, with full particulars of training, subsequent experience and qualifications, to your nearest EMPLOYMENT EXCHANGE quoting No. A 3960 and ENGINEERING. J 317

Draughtsmen. — Several JUNIORS WANTED quickly for Government work in Midland engineering works. Permanent jobs for suitable men.—Apply under reference No. A3960, stating age, experience fully, salary expected, and when at liberty, to your nearest EMPLOYMENT EXCHANGE. No person already on Government work will be engaged. J 287

Draughtsmen (two), Mechani- cal, REQUIRED, by Midland manufacturing firm. Preference given to men with experience of modern steam and electrical plant and general mill work.—Apply, giving age, experience, salary required, and references, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A. 3987. No one on Government work will be engaged. J 220

Draughtsmen Wanted for Jigs and Tools for urgent Government work; must be first-class men and able to act on own initiative. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and reference J 365.

Draughtsman Required immediately, for small detail work. Must be neat and quick. In West London District. Only those not already upon Government work, and residing within a ten-mile radius, need apply, stating age, experience and salary required.—Address, J 240, Offices of ENGINEERING.

Draughtsmen Required for High-class Aero Engine Design. Good prospects for the right men. Experience in internal combustion engine desirable. Apply, stating full particulars and salary desired, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 318. No person already engaged on Government work need apply.

Two Draughtsmen Required for blast furnace and steel works plant extension in Lincolnshire. State age, experience and salary required. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and A 3967. J 357

Wanted, Draughtsman with good Engineering Training, able to design the mechanical portion of electric machinery; well versed in calculation of stresses, sizes of shafts, gearing, &c., and possessing a knowledge of shop methods. State full particulars, including age, qualifications, and salary expected. No person already engaged on Government work will be employed.—Apply to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 335.

Wanted, Draughtsman, for large modern boiler and pipework arrangements and details.—Apply by letter, stating age, wages, full particulars, to the YORKSHIRE ELECTRIC POWER COMPANY, Wallington Road, Dewsbury. Only men free to leave present employment need apply. J 314

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THE WHIRLING OF SHAFTS.

By H. A. Webb, M.A.

(*Continued from page* 456.)

§5. Rigorous Mathematical Solutions.

The equation (1) can be solved, and the accurate solution of the whirling problem completed, in the following four cases, which will be considered in turn :—

(α) A cylindrical shaft : I and w are constants.

(β) A solid shaft consisting of one or more conical pieces, as in Fig. 3. For each piece of the shaft—

$$I = I_0 (q + r x)^4,$$
$$w = w_0 (q + r x)^2,$$

where I_0, w_0, q and r are constants.

(γ) A hollow shaft, with all its weight in its rim, consisting of one or more conical pieces, as in Fig. 3. For each piece of the shaft—

$$I = I_0 (q + r x)^5,$$
$$w = w_0 (q + r x),$$

where I_0, w_0, q and r are constants.

(δ) A solid shaft whose meridian curve consists of one or more parabolic arcs, all of them, produced if necessary, touching the axis. For each piece of the shaft—

$$I = I_0 (q + r x)^3,$$
$$w = w_0 (q + r x)^4,$$

where I_0, w_0, q and r are constants (Fig. 4).

(α) *The Cylindrical Shaft.*

From (1)

$$E I_0 \frac{d^4 y}{d x^4} = \frac{w_0}{g} \cdot p^2 y$$

where I_0 and w_0 refer to the cross-sections of the shaft. The whirling speed (for references see §2) is given by

$$p = \frac{\pi^2}{L^2} \sqrt{\frac{g E I_0}{w_0}} \text{ radians per second} \quad . \quad . \quad (4)$$

The solution, on Barling's hypothesis, is as follows :—

From (2)

$$\frac{d^2 y}{d x^2} + p y \sqrt{\frac{w_0}{g E I_0}} = 0.$$
$$\therefore y = A \sin m x + G \cos m x,$$

where $$m^2 = p \sqrt{\frac{w_0}{g E I_0}}$$

and A and G are arbitrary constants.

But $$\left.\begin{matrix} y = 0 \text{ when } x = 0 \\ \text{and when } x = L \end{matrix}\right\},$$
$$\therefore G = 0 \text{ and } A \sin m L = 0.$$

$\therefore$ the whirling speed is given by

$$\sin m L = 0.$$

Hence the lowest value of p is given by

$$m L = \pi,$$
$$\therefore p = \frac{\pi^2}{L^2} \sqrt{\frac{g E I_0}{w_0}} \text{ radians per second} \quad . \quad (4)$$

The correction given by the empirical rule (3) is zero, since R = 0.

Hence, for a cylindrical shaft, Barling's hypothesis gives the correct result, and there appears to be no interchange of energy between consecutive elements of the shaft.

(β) *Solid Truncated Double Conical Shaft.*

Consider the problem of finding the whirling speed of a solid truncated double conical shaft, symmetrical about its central section, as in Fig. 5, supported on free bearings at A and B.

$$I = I_0 \cdot \frac{(l - x)^4}{l^4},$$
$$w = w_0 \cdot \frac{(l - x)^2}{l^2},$$

where I_0 and A_0 refer to the central cross-section of the shaft.

$\therefore$ from (1)

$$\frac{d^2}{d x^2} \left\{ (l - x)^4 \frac{d^2 y}{d x^2} \right\} = \frac{w_0 p^2 l^2}{E I_0} (l - x)^2 y.$$

Put

$$l - x = \frac{v}{l p} \sqrt{\frac{g E I_0}{w_0}} \quad . \quad . \quad . \quad (5)$$
$$\therefore \frac{d^2}{d v^2} \left\{ v^4 \frac{d^2 y}{d v^2} \right\} = v^2 y,$$

or

$$v^2 \frac{d^4 y}{d v^4} + 8 v \frac{d^3 y}{d v^3} + 12 \frac{d^2 y}{d v^2} = y.$$

The solution of this equation by means of Bessel functions is given in Jahnke and Emde's "Funktionentafeln" (Teubner), page 168. We have followed Jahnke and Emde's notation in the numerical work that follows, except that $L_n(i x)$ is written for $\frac{i \pi}{2} H_n^{(1)}(i x)$, in the table on page 135.

We find that

$$y = B J_2 (2 \sqrt{v}) + C Y_2 (2 \sqrt{v}) + E i J_2 (2 i \sqrt{v}) + F L_2 (2 i \sqrt{v}) \quad . \quad . \quad (6)$$

where B, C, E and F are constants of integration.

The terminal conditions are :—

When $x = 0$ the slope of the deflection-curve is zero, and the shear is zero ;

When $x = l - k$, the deflection and the bending moment are zero.

i.e., when $x = 0$

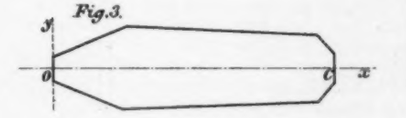
$$\frac{d y}{d x} = 0 \quad \text{and} \quad \frac{d}{d x} \left\{ E I \frac{d^2 y}{d x^2} \right\} = 0;$$

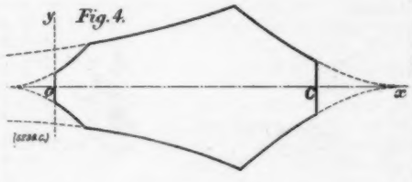
and when $x = l - k$

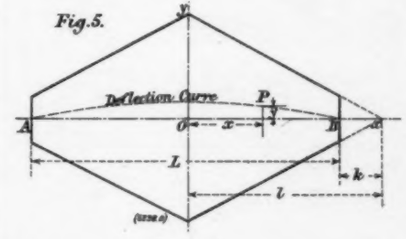
$$y = 0 \quad \text{and} \quad E I \frac{d^2 y}{d x^2} = 0;$$

i.e., when

$$v = l^2 p \sqrt{\frac{w_0}{g E I_0}}, \quad \frac{d y}{d v} = 0 \text{ and } \frac{d}{d v} \left(v^4 \frac{d^2 y}{d v^2} \right) = 0,$$







and when

$$v = l k p \sqrt{\frac{w_0}{g E I_0}}, \quad y = 0 \text{ and } \left(v^4 \frac{d^2 y}{d v^2} \right) = 0.$$

As a numerical example, let

$$p = \frac{4}{l^2} \sqrt{\frac{g E I_0}{w_0}} \quad . \quad . \quad . \quad . \quad (7)$$

so that at O, when $x = 0$, $v = 4$.

At B, when $x = l - k$,

let $v = \frac{1}{4} u^2$,

$\therefore$ From (5) and (7),

$$u = 4 \sqrt{\frac{k}{l}} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

We are to find u, and hence k, from the terminal conditions, and so find the shape of the shaft whose whirling speed is given by (7).

From (6) we have, from properties of Bessel functions,

$$\frac{d y}{d v} = -v^{-\frac{1}{2}} \left\{ B J_3 (2 \sqrt{v}) + C Y_3 (2 \sqrt{v}) + E i J_3 (2 i \sqrt{v}) + F i L_3 (2 i \sqrt{v}) \right\}.$$
$$\frac{d^2 y}{d v^2} = v^{-2} \{ B J_4 (2 \sqrt{v}) + C Y_4 (2 \sqrt{v}) - E J_4 (2 i \sqrt{v}) - F L_4 (2 i \sqrt{v}) \}$$
$$\frac{d}{d v} \left(v^4 \frac{d^2 y}{d v^2} \right) = v^{\frac{1}{2}} \{ B J_3 (2 \sqrt{v}) + C Y_3 (2 \sqrt{v}) - E i J_3 (2 i \sqrt{v}) - F i L_3 (2 i \sqrt{v}) \}$$

$\therefore$ from the terminal conditions at O,

$$B J_3 (4) + C Y_3 (4) + E i J_3 (4 i) + F i L_3 (4 i) = 0,$$
$$\text{and } B J_3 (4) + C Y_3 (4) - E i J_3 (4 i) - F i L_3 (4 i) = 0,$$
$$\text{and } \therefore \quad \left.\begin{matrix} B J_3 (4) + C Y_3 (4) = 0 \\ \text{and} \quad E i J_3 (4 i) + F i L_3 (4 i) = 0 \end{matrix}\right\} . \quad . \quad (9)$$

From the terminal conditions at the bearing B

$$\left.\begin{matrix} B J_2 (u) + C Y_2 (u) + E J_2 (u i) + F I_2 (u i) = 0 \\ \text{and} \\ B J_4 (u) + C Y_4 (u) - E J_4 (u i) - F L_4 (u i) = 0 \end{matrix}\right\} \quad (10)$$

From (9)

$$B = 0.5485 C \quad \text{and} \quad E = 0.00896 F.$$

Substitute these values of B and E in (10), and eliminate C and F.

$$\therefore \{0.0090 J_2 (u i) + L_2 (u i)\} \{0.5485 J_4 (u) + Y_4 (u)\} + \{0.0090 J_4 (u i) + L_4 (u i)\} \{0.5485 J_2 (u) + Y_2 (u)\} = 0 \quad (11$$

is the equation for u.

It may be verified that the smallest positive root of this equation is

$$u = 2.38.$$

From (8)

$$k = \frac{l u^2}{16} = 0.354 l.$$
$$\therefore L = 2 (l - k) = 1.292 l.$$

$\therefore$ from (7)

$$p = \frac{6.68}{L^2} \sqrt{\frac{g E I_0}{w_0}} \quad . \quad . \quad . \quad (12)$$

This is the accurate value of p. We will now calculate p on Barling's hypothesis, and compare results.

On Barling's hypothesis

$$(l - x) \frac{d^2 y}{d x^2} + p l \sqrt{\frac{w_0}{g E I_0}} \cdot y = 0,$$
$$\therefore \quad v \frac{d^2 y}{d v^2} + y = 0$$
$$\therefore y = \sqrt{v} \{ A J_1 (2 \sqrt{v}) + G Y_1 (2 \sqrt{v}) \},$$
$$\text{and } \frac{d y}{d v} = A J_0 (2 \sqrt{v}) + G Y_0 (2 \sqrt{v}),$$

where A and G are constants of integration.

The terminal conditions are that

$$\text{at O, when } x = 0, \quad \frac{d y}{d v} = 0,$$
$$\text{and at B, when } x = 0{\cdot}646 l, \ y = 0.$$

Let $$\frac{1}{4} \lambda^2 = l^2 p \sqrt{\frac{w_0}{g E I_0}} \quad . \quad . \quad . \quad (13)$$

$\therefore$ when $$2 \sqrt{v} = \lambda, \frac{d y}{d v} = 0,$$

and when $$2 \sqrt{v} = 0.595 \lambda, y = 0.$$
$$\therefore A J_0 (\lambda) + G Y_0 (\lambda) = 0,$$
$$\text{and } A J_1 (0.595 \lambda) + G Y_1 (0.595 \lambda) = 0.$$

Eliminate A and G :

$$\therefore J_0 (\lambda) \cdot Y_1 (0.595 \lambda) = J_1 (0.595 \lambda) \cdot Y_0 (\lambda)$$

is the equation for λ.

It may be verified that the smallest positive root of this equation is

$$\lambda = 4.29,$$
$$\therefore p = \frac{7.68}{L^2} \sqrt{\frac{g E I_0}{w_0}}$$

The correction given by (3) is found as follows :—

R = average *numerical* value of $\frac{d}{d x} \sqrt{I w}$ along the shaft

$$= \frac{1}{l - k} \cdot \int_{x=0}^{x=l-k} \sqrt{I_0 w_0} \cdot \frac{3 (l - x)^2}{l^3} \cdot d x$$
$$= \sqrt{I_0 w_0} \cdot \frac{l^2 + l k + k^2}{l^3}.$$

Similarly

$$S = \sqrt{I_0 w_0} \cdot \frac{(l + k) (l^2 + k^2)}{4 l^3}.$$
$$\therefore \quad \frac{5}{9} \cdot \frac{L^2 R^2}{S^2} = \frac{5}{9} \cdot \frac{64 (l^3 - k^3)^2}{(l + k)^2 (l^2 + k^2)^2} = 14.$$

$\therefore$ by (3) we must subtract 14 per cent. from the value of p found above ; and the corrected value is

$$p = \frac{6.61}{L^2} \sqrt{\frac{g E I_0}{w_0}} \quad . \quad . \quad . \quad (14)$$

A comparison of (12) and (14) shows that in this case the corrected value of the whirling speed found on Barling's hypothesis is 1 per cent. too low.

Another numerical case of the symmetrical solid truncated double conical shaft has been worked out, with the following result :—

When

$$k = (0.3055)\,l,$$

$$p = \frac{6.25}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}} \text{ accurately.}$$

On Barling's hypothesis,

$$p = \frac{7.50}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}},$$

from which, by (3), 17 per cent. is to be subtracted, and the corrected value is

$$p = \frac{6.23}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}},$$

which is right within 1 per cent.

(γ) *Hollow Truncated Conical Shaft.*

Consider the hollow conical shaft in Fig. 6, supported on free bearings at O and C. All the mass is assumed to be in the rim.

$$I = I_0 \cdot \frac{(l-x)^3}{l^3},$$

$$w = w_0 \cdot \frac{(l-x)}{l},$$

where I_0 and w_0 refer to the cross-section of the shaft at the end O.

From (1),

$$\frac{d^2}{d\,x^2}\left\{(l-x)^3\,\frac{d^2\,y}{d\,x^2}\right\} = \frac{w_0\,p^2\,l^3}{g\,E\,I_0}\,(l-x)\,y.$$

As before, put

$$l - x = \frac{v}{l\,p}\sqrt{\frac{g\,E\,I_0}{w_0}} \quad . \quad . \quad . \quad (5)$$

$$\therefore \frac{d^2}{d\,v^2}\left(v^3\frac{d^2\,y}{d\,v^2}\right) = v\,y,$$

$$\therefore v^2\frac{d^4\,y}{d\,v^4} + 6\,v\,\frac{d^3\,y}{d\,v^3} + 6\,\frac{d^2\,y}{d\,v^2} = y,$$

$$\left.\begin{aligned}\therefore y\sqrt{v} = {} & B\,J_1(2\sqrt{v}) + C\,Y_1(2\sqrt{v}) + \\ & E\,i\,J_1(2\,i\sqrt{v}) + F\,i\,I_1(2\,i\sqrt{v})\end{aligned}\right\} \quad . \quad . \quad (15)$$

$$\therefore v\frac{d\,y}{d\,v} = -B\,J_2(2\sqrt{v}) - C\,Y_2(2\sqrt{v}) + E\,J_2(2\,i\sqrt{v}) + F\,I_2(2\,i\sqrt{v}),$$

$$\text{and } v^{\frac{3}{2}}\frac{d^2\,y}{d\,v^2} = B\,J_3(2\sqrt{v}) + C\,Y_3(2\sqrt{v}) - E\,i\,J_3(2\,i\sqrt{v}) - F\,i\,I_3(2\,i\sqrt{v}),$$

where B, C, E and F are constants of integration.

The terminal conditions are that the deflection and the bending moment are zero at both the bearings O and C, *i.e.*, that when $x = 0$ and $x = l - k$

$$y = 0 \text{ and } E\,I\frac{d^2\,y}{d\,x^2} = 0,$$

i.e., that when

$$v = l\,p\sqrt{\frac{w_0}{g\,E\,I_0}},$$

and when

$$v = l\,k\,p\sqrt{\frac{w_0}{g\,E\,I_0}},$$

$$y = 0 \text{ and } \frac{d^2\,y}{d\,v^2} = 0.$$

As a numerical example, let

$$p = \frac{9}{l^2}\sqrt{\frac{g\,E\,I_0}{w_0}} \quad . \quad . \quad . \quad . \quad (16)$$

and let

$$\lambda = 6\sqrt{\frac{k}{l}} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$\therefore$ when

$$x = 0,\ v = 9 \text{ and } y = 0,\ \frac{d^2\,y}{d\,v^2} = 0.$$

When

$$x = l - k,\ v = \tfrac{1}{2}\lambda^2 \text{ and } y = 0,\ \frac{d^2\,y}{d\,v^2} = 0.$$

$$\left.\begin{aligned}\therefore\ & B\,J_1(6) + C\,Y_1(6) + E\,i\,J_1(6\,i) + F\,i\,I_1(6\,i) = 0\\ & B\,J_3(6) + C\,Y_3(6) - E\,i\,J_3(6\,i) - F\,i\,I_3(6\,i) = 0\\ & B\,J_1(\lambda) + C\,Y_1(\lambda) + E\,i\,J_1(\lambda\,i) + F\,i\,I_1(\lambda\,i) = 0\\ \text{and } & B\,J_3(\lambda) + C\,Y_3(\lambda) - E\,i\,J_3(\lambda\,i) - F\,i\,I_3(\lambda\,i) = 0\end{aligned}\right\}$$

After some reduction we find that

$$E = -0.00756\,B - 0.01333\,C$$
$$\text{and } F = -138.7\,B - 376.0\,C,$$

and hence obtain the equation for λ,

$$\left.\begin{aligned}&\{J_1(\lambda) - 0.00756\,i\,J_1(\lambda\,i) - 138.7\,i\,I_1(\lambda\,i)\}\\ &\{Y_3(\lambda) + 0.01333\,i\,J_3(\lambda\,i) + 376\ \ i\,I_3(\lambda\,i)\}\\ =\ &\{Y_1(\lambda) - 0.01333\,i\,J_1(\lambda\,i) - 376\ \ i\,I_1(\lambda\,i)\}\\ &\{J_3(\lambda) + 0.00756\,i\,J_3(\lambda\,i) + 138.7\,i\,I_3(\lambda\,i)\}\end{aligned}\right\} \quad (18)$$

It may be verified that the smallest positive root of the equation (18) is

$$\lambda = 2.90.$$

$\therefore$ from (17), $k = 0.234\,l,$

$$\therefore L = l - k = 0.766\,l.$$

$\therefore$ from (16), $p = \frac{5.28}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}}$ (19)

This is the accurate value of p. We will now calculate p on Barling's hypothesis and compare results.

On Barling's hypothesis,

$$(l-x)\frac{d^2\,y}{d\,x^2} + p\,l\,y\sqrt{\frac{w_0}{g\,E\,I_0}} = 0,$$

$$\therefore\ v\frac{d^2\,y}{d\,v^2} + y = 0,$$

$$\therefore\ y = \sqrt{v}\,\{A\,J_1(2\sqrt{v}) + G\,Y_1(2\sqrt{v})\},$$

where A and G are constants of integration.

Let

$$\frac{1}{4}\,\mu^2 = l^2\,p\sqrt{\frac{w_0}{g\,E\,I_0}} \quad . \quad . \quad . \quad (20)$$

The terminal conditions are that $y = 0$ at O and C, *i.e.*, when $x = 0$ and when $x = L = 0.766\,l$, *i.e.*, when $2\sqrt{v} = \mu$ and when $2\sqrt{v} = (0.484)\,\mu$.

$$\therefore\ A\,J_1(\mu) + G\,Y_1(\mu) = 0,$$

$$\text{and } A\,J_1(0.484\,\mu) + G\,Y_1(0.484\,\mu) = 0,$$

$$\therefore\ J_1(\mu)\,.\,Y_1(0.484\,\mu) = J_1(0.484\,\mu)\,.\,Y_1(\mu)$$

is the equation for μ.

Fig. 6.

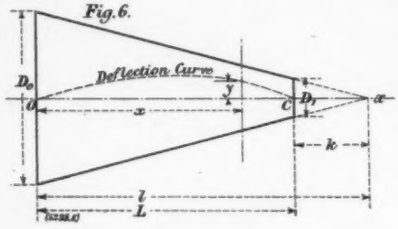
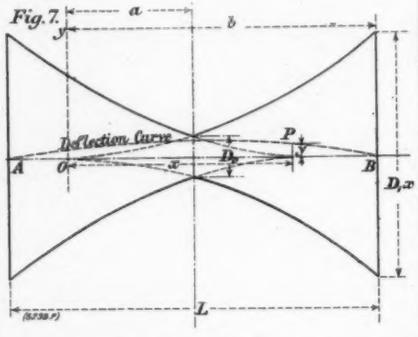


Fig. 7.



It may be verified that the smallest positive root of this equation is

$$\mu = 6.20.$$

$\therefore$ from (20),

$$p = \frac{5.64}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}}.$$

The correction given by (3) is found as follows :—

$$R = \sqrt{I_0\,w_0}\cdot\frac{l+k}{l^2},$$

and

$$S = \sqrt{I_0\,w_0}\cdot\frac{1}{3}\cdot\frac{l^2 + l\,k + k^2}{l^2},$$

and

$$L = l - k,$$

$$\therefore\ \frac{5}{9}\cdot\frac{L^2\,R^2}{S^2} = \frac{5\,(l^2-k^2)^2}{(l^2 + l\,k + k^2)^2} = 2.7.$$

Also

$$\frac{e}{L} = \frac{L}{6\,(2\,l - L)} = 0.104.$$

$$\therefore\ \frac{3500\,e^5}{L^5} = 3.9$$

$\therefore$ by (3) we must subtract $2.7 + 3.9) = 6.6$ per cent. from the value of p found above; and the corrected value is

$$p = \frac{5.27}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}}, \quad . \quad . \quad . \quad (21)$$

which, by (19), is right within 1 per cent.

Solid Truncated Conical Shaft.

For a solid shaft as in Fig. 6

$$I = I_0\cdot\frac{(l-x)^4}{l^4},$$

$$w = w_0\cdot\frac{(l-x)^2}{l^2}.$$

The mathematical treatment is similar to that of the solid truncated double conical shaft already considered; a numerical case has been worked out, with the following result :—

When

$$D_1 = 0.258\,D_0,$$

$$p = \frac{4.96}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}} \text{ accurately.}$$

On Barling's hypothesis

$$p = \frac{5.80}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}},$$

from which, by (3), 9.2 per cent. is to be subtracted for the eccentricity of the centre of gravity, and 4.8 per cent. for the variation of $\sqrt{I\,w}$, or a total of 14 per cent.

The corrected value is

$$p = \frac{4.99}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}},$$

which is right within 1 per cent.

(δ) *Solid Truncated Double Paraboloidal Shaft.*

Consider the problem of finding the whirling speed of a solid truncated double paraboloidal shaft, symmetrical about its central section, as in Fig. 7, supported on free bearings at A and B.

Take axes, as in the figure, through the vertex O of the parabolic meridian section; let c be the *latus rectum* of this section.

Then

$$\left.\begin{aligned}a^2 &= c\,D_0,\\ b^2 &= c\,D_1,\\ L &= 2\,(b-a)\\ x^2 &= c\,D,\\ \frac{w}{w_0} &= \frac{x^4}{a^4},\\ \frac{I}{I_0} &= \frac{x^3}{a^3},\end{aligned}\right\} \quad . \quad . \quad . \quad (22)$$

where I_0 and w_0 refer to the central cross-section of the shaft.

$\therefore$ from (1)

$$\frac{d^2}{d\,x^2}\left\{x^3\,\frac{d^2\,y}{d\,x^2}\right\} = \frac{w_0\,p^2\,a^4}{g\,E\,I_0}\cdot x^4\,y.$$

It may be verified that $y = x^n$ satisfies this equation if

$$n\,(n-1)\,(n+5)\,(n+6) = \frac{w_0\,p^2\,a^4}{g\,E\,I_0}.$$

$$\therefore\ n = -2\tfrac{1}{2} \pm \sqrt{9\tfrac{1}{4} \pm \sqrt{9 + \frac{w_0\,p^2\,a^4}{g\,E\,I_0}}}.$$

Call these values of n, n_1, n_2, n_3, n_4. The complete solution of the differential equation is

$$y = B\,x^{n_1} + C\,x^{n_2} + E\,x^{n_3} + F\,x^{n_4} \quad . \quad (23)$$

where B, C, E and F are constants of integration.

The terminal conditions are :

When $x = a$ the slope of the deflection-curve is zero and the shear is zero ;

When $x = b$ the deflection and the bending moment are zero.

i.e., when $x = a$

$$\frac{d\,y}{d\,x} = 0,$$

$$\text{and } \frac{d}{d\,x}\left(x^3\,\frac{d^2\,y}{d\,x^2}\right) = 0,$$

and when $x = b$

$$y = 0,$$

$$\text{and } x^3\frac{d^2\,y}{d\,x^2} = 0.$$

As a numerical example, let

$$\frac{w_0\,p^2\,a^4}{g\,E\,I_0} = \frac{25}{16} \quad . \quad . \quad . \quad (24)$$

$$n = -2\tfrac{1}{2} \pm \sqrt{9\tfrac{1}{4} \pm 3\tfrac{1}{2}},$$

$$= -2\tfrac{1}{2} \pm \sqrt{6}, \text{ or } -2\tfrac{1}{2} \pm \frac{5}{\sqrt{2}}$$

$$\left.\begin{aligned}\therefore\ n_1 &= -0.051\\ n_2 &= -4.949\\ n_3 &= -6.036\\ n_4 &= \ \ 1.036\end{aligned}\right\}$$

The terminal conditions give four equations from which B, C, E and F can be eliminated, and we find, after some reduction, that

$$\left(\frac{a}{b}\right)^{11\cdot97} - (316)\left(\frac{a}{b}\right)^{7\cdot07} - (13.12)\left(\frac{a}{b}\right)^{4\cdot90} + 0.706 = 0$$

whence

$$\frac{a}{b} = 0.406.$$

$\therefore$ from (22)

$$\frac{D_0}{D_1} = 0.165,$$

$$L = 2.92\,a = 1.19\,b,$$

$$\text{and } c = (0.117)\,\frac{L^2}{D_0},$$

and from (24)

$$p = \frac{5}{4\,a^2}\sqrt{\frac{g\,E\,I_0}{w_0}},$$

$$\therefore\ p = \frac{10.66}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}} \quad . \quad . \quad . \quad (25)$$

This is the accurate value of p. We will now calculate p on Barling's hypothesis, and compare results.

On Barling's hypothesis

$$x^2\frac{d^2y}{dx^2} + \sqrt{\frac{w_0\,p^2\,a^4}{g\,E\,I_0}}\cdot y = 0.$$

Let

$$\sqrt{\frac{w_0\,p^2\,a^4}{g\,E\,I_0}} = \frac{1}{4} + \beta^2 \quad . \quad . \quad (26)$$

$$\therefore y = \sqrt{x}\left\{A\cos(\beta\log_e x) + G\sin(\beta\log_e x)\right\},$$

where A and G are constants of integration.

The terminal conditions are,

when

$$x = a,\ \frac{dy}{dx} = 0,$$

and when

$$x = b,\ y = 0.$$

These give two equations from which A and G can be eliminated, and we find after some reduction that

$$\tan\left(\beta\log_e\frac{b}{a}\right) = 2\beta \quad . \quad . \quad . \quad (27)$$

In the numerical case in which $\frac{a}{b} = 0.406$ we find from (27) that

$$\beta = 1.33,$$

and $\therefore$ from (26)

$$\sqrt{\frac{w_0\,p^2\,a^4}{g\,E\,I_0}} = 2.01,$$

and $\therefore$

$$p = \frac{17.2}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}}.$$

The correction given by (3) is found as follows:—

$$R = \sqrt{I_0\,w_0}\cdot\frac{b^5 - a^5}{a^5\,(b-a)},$$

$$S = \sqrt{I_0\,w_0}\cdot\frac{b^7 - a^7}{7\,a^5\,(b-a)},$$

and $\quad L = 2\,(b-a),$

$$\therefore\ \frac{5}{9}\frac{L^2\,R^2}{S^2} = \frac{980}{9}\cdot\frac{(b-a)^2\,(b^5-a^5)^2}{(b^7-a^7)^2} = 38, \text{ since } \frac{a}{b} = 0.406.$$

$\therefore$ by (3) we must subtract 38 per cent. from the value of p found above; and the corrected value is

$$p = \frac{10.7}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}} \quad . \quad . \quad . \quad (28)$$

which, from (25), is correct within 1 per cent.

(To be continued.)

NATIONALISATION OF INDUSTRIES.—This process seems to go on in different directions, and the latest important transaction is of some interest to the English paper industry, inasmuch as it refers to the Kellner-Partington undertakings in Norway and Sweden, the world's largest concern in the cellulose and kindred branches. The amount involved is stated to be between 7,000,000*l.* and 8,000,000*l.*, and the Bank of Norway itself is, on good authority, stated to be the financing party in the deal, which has been received with much satisfaction in Norway, the more so as the capital, it is understood, will be offered for public subscription. Less satisfaction is felt in Sweden at the fact that the Swedish property of the Kellner-Partington Company has not passed into Swedish possession. Taking the items of wood pulp and cellulose alone, the company's production amounts to some 150,000 tons per annum.

EDUCATION IN GERMANY.—In a recent report issued by the London County Council an article is given on "Education in Germany," from which we note that in Berlin a scheme has been outlined, and, if approved, was to be carried out in the course of the present month, for creating a new type of gymnasium and Realschule to link up with Class VI of the elementary school. The pupils will be very carefully selected and will receive, if necessary, free places, free books and a yearly maintenance grant of 300 marks, the latter being given only after two years' attendance at the secondary school. The defect of the plan seems to be that it entails the segregation of the "gifted" elementary scholar. The report adds that these changes, inconsiderable as they may appear, are nevertheless significant because, having once admitted the desirability of bridging the gulf between elementary and higher education for the gifted few, the Government will have difficulty in keeping the new arrangements within narrow limits, as it obviously desires to do.

KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE.

(Continued from page 463.)

WE continue our series of illustrations of the Scherzer roller lift railway and road bridge over the river Keadby for the Great Central Railway. In our former article we finished by describing the rear or roller end of the lifting span, and on Plates XLVII to XLIX we illustrate the ballast box carried on the span and the track girder on which the span rolls. Fig. 44, on Plate XLVII, is a perspective view and Figs. 45 to 47, on Plate XLVIII, sectional drawings of the ballast box, the immense proportions of which are demonstrated by the perspective view.

The ballast box is 54 ft. 11 in. long by 35 ft. 6 in. deep by 15 ft. 8 in. at the top, tapering to 10 ft. 7 in. at the bottom. The skin plates are $\frac{1}{4}$ in. thick, butt-jointed, the joints being covered by external cover plates. The interior is well braced in all directions, and full details of this bracing are shown on Figs. 45 to 47 on Plate XLVIII.

Referring to Plate XLV, accompanying our issue of November 2, it will be seen that a well-braced double web frame is provided throughout the cross-section of the box in the plane of the rolling segments and the top booms. This frame consists of two $\frac{1}{2}$-in. web plates 7 ft. deep at the bottom, forming a continuation of the segment, and two $\frac{1}{2}$-in. plates 8 ft. 2 in. deep at the top, to which the top boom of the main girder is riveted. Between these run plate girders next to the skin plates. That at the back of the box is 3 ft. deep with $\frac{1}{2}$-in. webs, and two 6-in. by 4-in. by $\frac{5}{8}$-in. angles at top and bottom, the latter being riveted to the skin plates. That at the front is 1 ft. 6 in. deep, with $\frac{1}{2}$-in. webs, and top and bottom angles 3$\frac{1}{2}$ in. by 3$\frac{1}{2}$ in. by $\frac{5}{8}$ in. Down the centre of the frame are four 6-in. by 6-in. by $\frac{5}{8}$-in. angles, to which are attached the longitudinal diagonal bracings shown on the right-hand side of Fig. 45, Plate XLVIII. These angles also are braced together with internal plate diaphragms top and bottom, as shown on the same figure. Diagonal angle bracings are also provided, as shown. At intervals of 5 ft. there are horizontal double angles 3$\frac{1}{2}$ in. by 3$\frac{1}{2}$ in. by $\frac{5}{8}$ in., laced together with 2$\frac{1}{2}$-in. by $\frac{1}{2}$-in. lacing bars. At the sides of the box the $\frac{1}{4}$ in. plating is continuous.

About midway between the main girders there are two further diagonal frames, illustrated in Fig. 45, Plate XLVIII, built up of 3$\frac{1}{2}$-in. by 3$\frac{1}{2}$-in. by $\frac{5}{8}$-in. angles, laced with 2$\frac{1}{2}$-in. by $\frac{1}{2}$-in. flats, the large gusset plates at the connection of the diagonal angle being $\frac{5}{8}$ in. thick. At intervals of 5 ft., as mentioned above, there are horizontal braced frames built up of 3$\frac{1}{2}$-in. by 3$\frac{1}{2}$-in. by $\frac{1}{2}$-in. angles laced together with 3$\frac{1}{2}$-in. by $\frac{5}{8}$-in. lacing bars. One of these is illustrated in Fig. 47, Plate XLVIII. Finally, a braced longitudinal frame is placed about midway between the front and the back of the box. This is shown for the one side of the box in Fig. 45, Plate XLVIII. It consists of 3$\frac{1}{2}$-in. by 3$\frac{1}{2}$-in. by $\frac{5}{8}$-in. angles laced with 2$\frac{1}{2}$-in. by $\frac{1}{2}$-in. bars, the members being disposed in a direction to take the tensile stresses in the concrete of the box. The left-hand half of Fig. 45, Plate XLVIII, shows the front of the box, illustrating the plating, and also showing the two doors leading to the front balancing recesses.

Voids or recesses, having a total capacity of over 3,000 cub. ft., were left in the top and in front of the counterweight box, and so disposed, relative to the centre of gravity of the whole mass, as to enable final balancing adjustments to be made. It was found necessary to fill these spaces up to approximately three-quarters of the volume in order to balance the completed leaf; this left one-quarter of the space available for future contingencies. As it was difficult to get ballast of the required specific weight, groups of scrap steel rails were included at intervals, to bring the final centre of gravity into the required position. The total counterweight is 1,800 tons, and the disposition of this is shown by diagrams in Mr. Ball's paper read before the Institution of Civil Engineers.

Plate XLIX illustrates details of the centre track girder. The outer girders are similar. The girder consists essentially of two separate plate girders. The top and bottom flanges are quite separate, being only connected by bearing plates at the ends, 38 in. by 1$\frac{3}{16}$ in. by 6 ft. 3 in., riveted to the bottom flanges, the end plates—the track plates—and the various packings. The position of these track girders is shown in the key elevation and plan, Fig. 48 on Plate XLVIII.

Taking the girder as a whole, it is 43 ft. long by 10 ft. deep. There are two $\frac{7}{8}$-in. web plates. The top flange, shown in detail in Fig. 58, is built up of two 8-in. by 8-in. by 1$\frac{1}{2}$-in. angles and 1-in. plates placed vertically. The bottom flange is made up of four angles 8 in. by 6$\frac{7}{8}$ in. by 1 in., and both vertical and horizontal plates as required by the flange stresses as shown on Figs. 50 to 59 on Plate XLIX. As with the segmental girders, a centre field joint, for convenience of transport, was arranged for, and this was riveted at the site by hydraulic power. The two halves of the girder are rigidly connected at each bearing by means of forged steel blocks, which extend from the base plate up to the track plates. Each block is rigidly bolted by 14 turned bolts, as shown on Fig. 57. Four cast-iron blocks are spaced between the bearing, as shown on Figs. 51, 55 and 56, and at the centre, where the cross girders join the main girder, a cast-iron block is placed as shown on Fig. 54. The top flange of the girder was machined to receive the track plates, but the angles were sent blank, the holes for the 1$\frac{1}{4}$-in. hold-down bolts of the track plates being drilled at the site after the plates had been finally set. Diagonal bracing consisting of 6-in. by 4-in. by $\frac{1}{2}$-in. angles, was provided level with the bottom of the cross girders. This is shown on Fig. 52. The connections of this bracing and of the cross girders to track girders were left blank and drilled at the site after the track girders had been set.

The perspective view (Fig. 60) on Plate L is a complement to that on Plate XLVII, the one shows the roller lift span lowered in position for railway traffic, taken from one approach, the other the span raised for the passage of river craft, taken from the other approach. On this latter view there can be seen the ends of the three roller lift track girders. The view is very deceptive in the respect that it is not easy to appreciate that between the ends of these track girders and the end of the fixed span upon which the camera stood while the photograph was being taken there is an opening of 150 ft. through which pass the ships navigating the river.

(To be continued.)

WOMEN ENGINEER STUDENTS.

WOMEN of education are determined more than ever to enter every profession that offers an opportunity for the exercise of mental faculty and for working out an independent life, and with whatever misgivings all interested in the future of the State regard this move, in view of the necessity of maintaining the State in man-power, the fact has to be accepted. The peculiar conditions of the moment and the depletion of the working forces of the nation make the new movement more acceptable, and in some respects commendable. The "learned professions" have opened their doors wide for educated women, but in the greatest industry of all—engineering—there are few opportunities for the hopes of engineering students reaching full fruition. The invasion of women into the munition factories has proved that their sex is no disability to their prosecution of work of a highly skilled nature, but many ladies who have gained an intimate knowledge of difficult and delicate operations look forward to the termination of war as likely to put a final stop to their aspirations. We are glad, therefore, to record that one of the great captains of industry of Scotland has specially organised and equipped an engineering factory for the employment exclusively of educated women of good social standing and in contradistinction to the woman factory worker, and with the fixed determination to carry on operations permanently under those conditions, the work to be taken up being that associated with the manufacture of internal-combustion motors. The work is managed by women, the head a "Girton girl," with those characteristics which are desirable for guiding and stimulating the girl students to success. Indeed, the factory has some of the salient features of a technical college combined with practical work in

the factory which gives that stimulus to study not realisable in the laboratory of a college

The factory is situated in the south of Scotland, in what may be fitly called "God's country" because of the variety and beauty of the scenery, so that the students of botany and of wild life generally can have full opportunity of pursuing their hobby. It is beside a river noted for its salmon fishing, and, without interfering in the slightest degree with this sport, the river has been partly "harnessed" to provide the electric power for driving, lighting and heating the factory. The factory itself, standing on the hillside, has glazed walls, so that there is an abundance of natural light, and everything is done to make it attractive to the feminine eye and mind. All the accessories which are now placed under the wide term "welfare" have been adopted to the fullest extent, and all the girls sit down to their meals in admirably arranged quarters. Unfortunately there is not yet sufficient boarding accommodation in the village for the considerable number of students already employed, but the county town is only two miles distant, and those who have not their bicycles—and the number is few—travel by *char-à-bancs*, provided by the company, to the county town, where the company have taken an hotel which is used as a hostel, and where also in other houses the welfare superintendent of the factory arranges for boarding. Indeed the students form a community in themselves, and in their leisure time combine in their studies, recreation and amusement.

The lecture room at the works constitutes an important element in the organisation. There, at stated hours, highly trained lecturers conduct classes which are compulsory for the students, and a regular curriculum has been arranged, so that the students of each grade become thoroughly conversant with the machines they are operating and with the work they are executing. The entrants to the works, who may be of any age, although from 20 to 30 years are the preferable limits, receive during what is termed the probationary period 20*s.* per week, but this period extends only for six weeks. They have then to decide whether or not they intend to pursue the engineering career. If such be the case and they are considered suitable candidates an agreement is entered into and the wages at once become 25*s.* per week until the first technical examination. This examination is comparatively simple to those who have entered the works with some knowledge of mechanics, have been punctual, careful and observant at their work, and have applied themselves with diligence to the lectures. According to the quality of the work at the examination and the marks received in the factory the student's wage will be increased by 5*s.* per week. Each six months there are examinations for each grade of student. The examinations are graded, and each "pass" means an increase of 5*s.* In the event of a student failing to pass any particular examination she can take two examinations at any subsequent period and gain thereby an increase of 10*s.* per week, so that it will be seen at once that special merit means a rapid recognition in the form of wages. In addition to the lecturer there are instructors in the shops, and as soon as the worker shows a proficiency in the simpler machines or in the simpler operations, she is at once advanced to work of a more intricate and exacting character, and thus there can be no monotony.

Some general information may be given regarding the measurement of merit. In order to qualify for an advance of wages the student must have received 90 per cent. each for attendance, punctuality, general conduct and cleanliness at machines, benches, &c.; 75 per cent. each for efficiency and accuracy—all of these being determined weekly: 75 per cent. of marks must also be gained at the examination. After passing the first examination the student is required to sign on for three years, and this three years is regarded as apprenticeship, but with the possibility of the student easily attaining during this period to a wage of 3*l.* or more per week, because the aim is to educate the student in all subjects appertaining to engineering up to the highest possible standard.

The apportionment of the marks may be of interest to our readers. The hours of attendance are 44 per week, with one break per day. The factory begins at 8 a.m. and continues until noon, when the students all dine together, and on resumption at 1 o'clock they continue till 5 o'clock p.m. One mark is deducted for each attendance lost; half a mark for a lapse from punctuality. Each week marks are given for general conduct and cleanliness of machines, &c., as follow: excellent, 100 marks; very good, 90 marks; good, 75 marks; fair, 55 marks. After going through the factory during operations and after work one could not help being struck with the degree of cleanliness which was attained. It equalled the best-kept mechanical laboratory we have visited.

As regards efficiency, the system adopted at the factory is also of special interest. A time is fixed for an operation. If the time allowed be exceeded by 10 per cent., one mark is lost; if it be reduced by the same proportion, one mark is gained; each student is allowed 75 per cent. efficiency marks at the commencement of the period, and at the end of it must not fall below this figure, so that she must make up the time lost on one job by time gained on another. To say that the conditions are admirable in respect of building up health cannot be doubted, so that the question of fatigue need not arise.

As regards accuracy the student is allowed 100 accuracy marks at the commencement of the period, and for any work that may be rejected accuracy marks are deducted in the proportion of 5 marks for every 1*l.* worth of work rejected. Where students drop below 75 marks, which is the standard of rejection, more than 5*l.* worth of work would be spoiled and would preclude "passing" in this subject. It should be noted, however, that novitiates are given simple work of little value, so that the penalty for accuracy falls upon the students according to their experience.

As regards the examinations, we may state that they embrace 18 questions, only eight of which need be attempted by the student. They cover a wide field in order to give the examinee considerable freedom in selecting the subjects, and to each question is allotted a number of marks varying from 5 to 15, so that it is not difficult to obtain 75 per cent. of the maximum marks in order to attain a pass. Neatness, especially in sketches, is an important advantage. We may give a specimen examination paper of the first grade, viz., those who have only been six weeks at the works:—

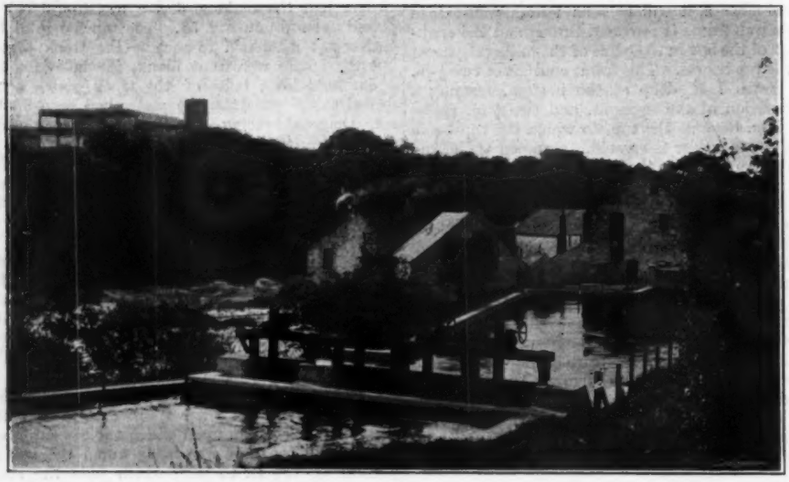


Fig. 5. Inlet Sluices.

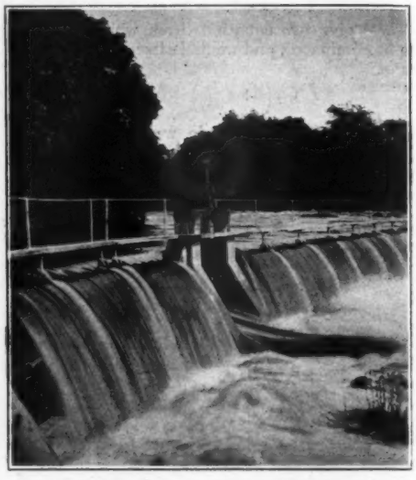


Fig. 6. Spillway.

	Marks.
1. What is the equivalent of 1 in. in millimetres?	5
2. State the size of drills you would use for the following holes:— ¼-in. Whitworth tapping. $\frac{9}{16}$-in. clear hole. ¾-in. reamering hole.	10
3. Give sketches of the following tools:— Parting tool. A tool for turning mild steel, and A tool for turning cast-iron.	15
4. What is meant by the following terms:— A running fit; a push fit and a force fit. State the allowance you would leave when turning an inch bar for these various fits.	10
5. What is the use of a micrometer? ...	15
6. What is the difference between a planing machine and a shaping machine?	15

We are not permitted to name the factory owing to its being engaged on work of great importance, but we give the assurance that those responsible for its organisation are actuated by the desire to give women an opportunity of prosecuting an engineering career under the most favourable and stimulating conditions, and the conditions are those best calculated for women of some education and social standing to attain a broad experience of engineering science and practice. Many of our readers, we are sure, are willing that those hereditary and mental qualities which make their daughters suited for the engineering career should be developed, and will desire to be put into communication with the establishment in order to gain fuller information, and any communications from such readers we shall be pleased to pass on to the factory.

The factory (see Fig. 5) is built on a high elevation overlooking the river, from which the hydro-electric power is derived. The machine shops, running east

and west, wholly on the ground floor, are enclosed by brick walls as a filling between steel columns. The roof principals are very substantial, with tie-beams of double-channel section back to back, with a ¾ in. clear space between—a scheme which enables the whole of the overhead shafting, counter-shafting and motors to be erected on the roof ties without drilling a single hole. The stores, running north and south, limit the machine shops at the east end, and beyond these is a four-storey ferro-concrete and glass building, housing, on the ground floor, offices, on the first and second floors, assembling and erecting shops, and on the third floor, the welfare department. This last-named section comprises bath and ambulance rooms, all-electric kitchen, staff and works mess-rooms, matron's room, library, writing room and recreation room.

Over all is, naturally, the roof, but it is no ordinary roof, but rather a plateau to which access is given by two staircases and an elevator. The flat deck of reinforced concrete is covered with rock asphalt and surrounded by a high parapet making it perfectly safe for recreation purposes. From the roof a widespread panorama is opened out of hill and dale, wood and river, with glimpses of the neighbouring county town and of tide water in the estuary. A portion of the roof is allocated to three water-supply tanks with an aggregate capacity of 20,000 gallons. The whole factory is warmed by a hot-water system of pipes and radiators with pump-aided circulation.

The machine-tool equipment does not differ materially from that of other works producing petrol motors, but it includes some fine examples of Herbert bar and chucking turret lathes, Dean, Smith and Grace engine lathes, Ward turret lathes, Churchill grinders, Brown and Sharpe and Cincinnati millers, B. and S. and Gleason gear cutters, Pratt and Whitney grinders and thread millers, &c. The three views on page 494 give a good idea of the machine shop and the mechanical equipment. Fig. 1 illustrates the grinding section, tool 114 is a milling cutter grinder, while close by are Churchill plain precision grinders working on crankcase bolts and pump spindles. Fig. 2 shows the engine-lathe section. This consists of a line of Dean, Smith and Grace sliding, surfacing and screw-cutting lathes, mainly engaged on chuck work. No. 38 is turning, boring and parting off rings from a brass casting to form special nuts for cylinder-jacket water joints. A lathe further back is on special, non-standard work, and another is turning the vertical-shaft bevel wheel for driving overhead camshaft. Fig. 3 is a view in the semi-automatic lathe section. The machines at the left hand are Ward turret lathes on small screws, bushes and rollers. Those on the right are Herberr hollow-spindle hexagon turret lathes on larget bolts, valves and the like. Fig. 7, subjoined, shows the boring operation on connecting-rod forgings—big and small ends opened out with reamers.

Apart altogether from the great natural beauty of their surroundings, the hydraulic development works have a peculiar interest in that they immediately adjoin and run side by side with the "doachs" or "batteries," the river works of another and very much more primitive industry—that of salmon fishing—an industry centuries old, established by the monks of the Abbey of Tongland, one of whom, John Damian, abbot of that ilk, according to a legend, in a demonstration before James IV of flying from the ramparts of Stirling Castle failed only because his wings, which should have been composed of eagles' pinions, were actually made of goose quills.

The flying scheme failed, but the salmon fishery continues to prosper, thanks to the engineering skill with which the monks enhanced the natural difficulties opposed by the rapids to the ascent of salmon. Here the water, concentrated to attract the fish by a good flow, is trapped at the head of the run. There, so distributed as not to prove attractive, it affords a free passage, with the consequence that at night, in the season, salmon are ladled out by the hundredweight. These same rapids form the foundation for the present power plant, which takes the place of three undershot water wheels previously, and for a hundred years, giving power to paper and corn mills. Just below the head of the rapids a concrete dam has been thrown out from the west bank, less than half-way across the river, which is here twice the normal width, serving to hold up the water on the western side to the height of a flat water or pool some 18 in. to 2 ft. (varying with the river flow) below the flat water above the rapids. This height is chosen so as to be below the entrance to, and not to interfere in any way with, the flow of water through the "Big Doach," the main flow on the eastern side, which has always formed the principal fish run. The course of the river is such that the full normal width is not encroached upon by the dam, which runs diagonally up stream. As will readily be supposed, the effect of the dam has been to throw more water than ever before to the eastern side, and being concentrated, the fish passage has been correspondingly improved. In particular a new run of easy gradient now exists round the eastern end of the dam. The intake sluices are on the site of the old ones, and generally the head race follows the line of the former mill lade. At about the middle of its length it emerges from the cutting and is then above ground-level. For a short distance the water is carried by mass concrete walls on a solid-filled foundation, and thereafter, being wholly above ground, a ferro-concrete channel on reinforced columns is used. This extends right down to the power-house.

The power-house is built on mass-concrete foundations, with mass-concrete walls round the turbine pits, the dynamo end being enclosed by brick walls with a flat concrete roof. The total fall at the power-house under favourable conditions is 23 ft. 9 in., made up of 10 ft. 6 in. pressure head above the turbine and 13 ft. 3 in. suction draught below. The power-house floor-line could not well be placed lower on account of the enormous floods to which the river is liable. These floods add no effective head above, but greatly reduce the suction head below the turbines, which have consequently been designed for a net head of 17 ft. They are double-ended reaction machines made by Gilkes

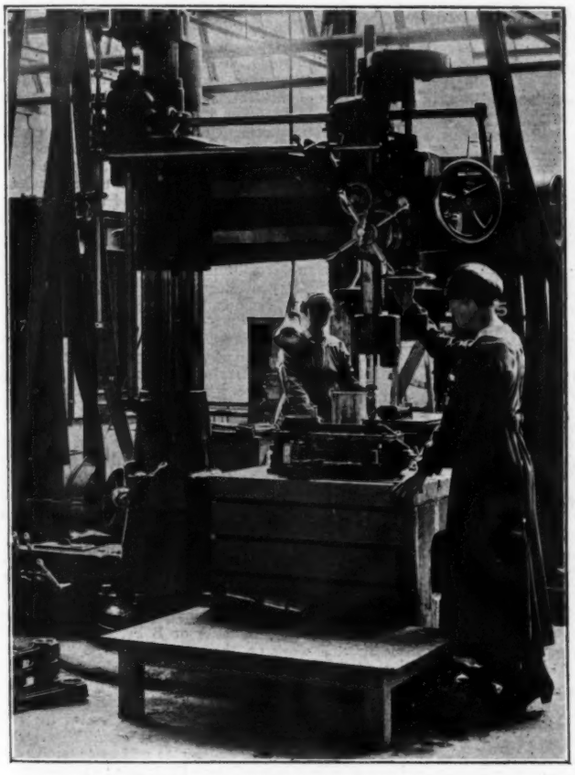


Fig. 7. Boring Connecting Rod Forgings.

Fig. 8. The Kitchen.

and Co., Kendal. Running at 375 r.p.m., each develops a maximum of 175 brake horse-power. The turbines are governed on the servo-motor system. A sensitive governor-head controls, through compensating gear, a balanced distributing valve admitting pressure oil to one side or other of a piston coupled to the turbine gate. The compensating oil cylinder has a controllable slip giving a time lag, and the effect is to produce a practically isochronous governor, the ultimate speed being sensibly constant regardless of load. The dynamos are direct-coupled compound-wound interpole direct-current machines by Mather and Platt, Limited, while the switchboard is by Westinghouse—both of Manchester. The western side of the factory is just opposite the power-house on the eastern bank, and the cables run directly from the one to the other in a single span.

These hydraulic works are illustrated on pages 486 and 494. Fig. 4, on the last-named page, shows the inlet sluices, spillway immediately to the right thereof, forebay, dam extending across the river, and in the distance at the far side the salmon fishery "doachs" or batteries. Fig. 5, on page 486, is a view of the reservoir looking down the river, and incidentally shows the picturesque environment of the factory, which, on the eastern bank, stands at an elevation of some 50 ft. above the river, flowing here in a very narrow rocky gorge. The old mill buildings, bounded on one side by the river and on the other by the old lade and present head-race, have not been interfered with, although not now occupied. They were formerly provided with three undershot wheels, utilising altogether 7 ft. to 8 ft. total head and developing probably 12 h.p. to 15 h.p., the water being gathered by a series of stone-filled timber dams extending from rock to rock half-way across the river. These dams were never tight, and allowed probably three to four times as much water to pass through as was diverted to the mill lade. They have been entirely cleared away and replaced by a mass-concrete gravity-section dam founded throughout on rock on the same general centre-line and of the same total length, but of greater height. This dam is provided with two 5-ft. wide sluices definitely located and opened to facilitate the descent of kelts (spent salmon) at the end of the spawning season. The dam carries a gangway giving access to these sluices. The entrance to the head-race, controlled by the four 5-ft. sluices seen in the foreground, is protected by steel bar "hecks" or gratings with the statutory 2-in. spacing. These serve both to keep out floating timber and to exclude the kelts above referred to. They have been effective for their intended purpose, for whereas in former years as many as a thousand kelts have had to be transferred by hand from the mill lade to the river, no single kelt, salmon or grilse has ever been seen in the new head-race, which, moreover, with a concrete floor, harbours no eels as did the former one. For a period of six weeks in the spring, when the young salmon (smolts) go down to the sea, these hecks are further protected by a fine-mesh wire grating, which has also proved effective. It is not known that anywhere else in Scotland have such complete protective measures been adopted in the interests of the salmon fishing. Fig. 6, page 486, shows the river in spate overflowing the dam crest. It will be noticed that the down-stream face of the dam is vertical; this, with a battered up-stream face, conduces to the stability of the otherwise light section. Buttresses are added on the down-stream side at 10-ft. centres, and a small amount of reinforcement was provided by casting in the iron and steel straps taken from the dismantled undershot water wheels.

The remaining view, Fig. 8, on page 487, shows the kitchen, probably one of the lightest, airiest and most cleanly of kitchens. It is situated on the third, the top floor, is lighted, as seen, by full-height windows, ventilated by numerous opening sashes and independent roof ventilators, warmed by hot-water pipes and radiators and powered by electricity—no coal, coke, gas or oil. In the remote corner is a potable water boiler-circulator. On the right-hand side is a two-oven range with boiling plates and grill, soup boiler, vegetable boiler and potato steamer, and in the left-hand corner is seen a hot cupboard. A tea urn, not visible, completes the equipment, which has been supplied by Ferranti, Limited, and installed by the company's own staff.

Excepting for the steel roof of the machine shop, the whole of the structural work, including the hydraulic works and the ferro-concrete building, has been carried out by direct labour under the supervision of Mr. W. L. Spence, M.Inst.Mech.E., Assoc.M.Inst.C.E., as consulting and resident engineer, assisted by Mr. Herbert Haughton, as ferro-concrete designer, and by Mr. Alex. Shields, as master of works.

INDUSTRIAL NOTES.

The Home Secretary has made an Order, which comes into force on December 1, requiring the provision of first aid and ambulance arrangements in blast-furnaces, copper mills, iron mills, foundries and metal works.

On October 4 the Shipping Controller announced that he hoped an agreement would be reached between representatives of shipowners and seamen for the fullest co-operation in matters affecting the *personnel* of the mercantile marine.

The Shipping Controller is now glad to announce that an agreement has been reached whereby the National Board will be at once constituted and will proceed without delay to discuss details of the national rates for all ratings. The shipowners' representatives on the board will meet separate panels of representatives of deck officers, engineers, seamen and firemen, and men of the catering department respectively. The chairman will be appointed by the Shipping Controller.

Owing to unavoidable delay in the nomination of representatives of the various associations concerned, it is not at present possible to announce the final scale of rates. In view of interim increases already announced the Controller considers the newly appointed board should be afforded full time to provide for the various services affected before announcing the complete scale. The rates fixed will apply retrospectively as from October 6 or from the date of first signing articles after that date.

The Minister of Munitions has ordered the following:—

1. No person shall, on or after November 1, until further notice, manufacture any ball bearing or roller bearing (both of which are hereinafter included in the expression "ball bearing"), or any part thereof except under and in accordance with the terms of a licence issued under the authority of the Minister of Munitions.

2. No person shall, on or after the same date, until further notice, sell, supply or deliver any ball bearing, or any part thereof, whether situated in or outside the United Kingdom, or purchase or negotiate for the purchase or take delivery of any ball bearing or any part thereof situated outside the United Kingdom except under and in accordance with the terms of a licence issued under the authority of the Minister of Munitions.

3. All persons engaged in the manufacture or sale of ball bearings shall make such returns with regard to their businesses as shall from time to time be required by or under the authority of the Minister of Munitions.

All applications in reference to this Order should be addressed to the Director of Ball Bearings, T.M.3, Ministry of Munitions, Whitehall-place, London, S.W. 1, and marked "Ball Bearings."

With reference to the recent dispute in Belfast concerning the remuneration of the power-loom tenters, it is announced that a settlement was reached at a conference held at the Ministry of Munitions between the Irish Power Loom Manufacturers' Association and the Power Loom Tenters' Trade Union, at which Mr. Stephen Walsh, M.P. (presiding), Colonel James Craig, M.P., and Mr. Joseph Devlin, M.P., were present as Parliamentary mediators in the dispute.

The terms of settlement signed on behalf of the Manufacturers' Association, the Union, the Parliamentary mediators and the Ministry of Munitions were as follow:—

"All tenters, damask and plain tenters, to receive an additional 3*s.* 6*d.* per week set pay, and 3*d.* in the £ commission, based on an average share of 19*l.*; evidence of this average share to be produced to the satisfaction of Colonel Craig, M.P., and Mr. Devlin, M.P.; it being understood that in case the average share does not amount to 19*l.*, the equivalent to the commission upon 19*l.* shall be so paid."

Provided that the above agreement is carried out, and in so far as it is carried, but not otherwise and no further, the Minister of Munitions and all parties concerned will regard the agreement as replacing the award of October 4.

The Minister of Reconstruction, after consultation with the President of the Local Government Board and the Secretary for Scotland, has appointed a committee to consider and report on the question of the supply of building materials after the war. The terms of reference are as follows:—

1. To inquire into the extent of the probable demand for building material for all purposes which will arise in this country during the transition period, and the extent of the available supply and form of such material.

2. To inquire how far the quantities of material now available are capable of increase; what are the difficulties in increasing them; and how these difficulties can be removed; and to report to what extent an increase in production will affect the price of the materials.

3. In the event of the supply of material or labour being insufficient to fulfil the total building demand, to consider the principles and method by which the priority of various claims should be settled; and to report what steps are necessary to ensure that the manufacture of the materials, so far as they are at present inadequate, shall be extended in time to secure sufficient quantities for use when required on the cessation of hostilities; and to recommend what steps should be taken during the war to facilitate a prompt commencement of building work at that time.

4. Generally to consider and report upon any conditions affecting the building trades which tend to cause unduly high prices, and to make recommendations in regard to any measure of control which it may be desirable to exercise over the charges, production, transport or distribution of material.

Correspondence and inquiries should be addressed to The Secretary, Building Materials Supply Committee, Ministry of Reconstruction, 2, Queen Anne's Gate Buildings, London, S.W. 1.

The Minister of Munitions has informed employers that it would be contrary to the policy of the Government in abolishing leaving certificates for an employer to refuse to engage a workman on the ground that he had left without his previous employer's consent. It has been represented to the Minister of Munitions and the Minister of National Service that such action on the part of employers might result in men who are needed in munition factories remaining out of work through no fault of their own, and, consequently, becoming liable to be called up for military service. In order, therefore, that such men should not be recruited for the army without their cases being thoroughly investigated the following arrangement has been made.

The Minister of Munitions and the Minister of National Service have agreed that if cases occur where the holder of an A or B Protection Certificate is refused work on the ground that he left his last employment without the consent of his employer, he shall have the right to lodge a claim with the Enlistment Complaints Sub-Committee. The sub-committee will investigate the case and will forward the claim with their report to the main committee for the division. The main committee will consider the case, and will hear any evidence that may be necessary. If the main committee are of opinion that the failure of the man to obtain work within 14 days was due to his being refused employment because he left his previous employment without the consent of his employer, they will certify that the man had reasonable grounds for not obtaining employment within 14 days, and therefore his failure to obtain within 14 days further work entitling him to protection will not of itself render him liable to recruitment.

At the second annual meeting of the shareholders of British Dyes, Limited, held at Huddersfield on Wednesday, October 31, the chairman of directors, Mr. James Falconer, M.P., stated the following in the course of his speech:—

"In dealing with our activity during the year I would like the shareholders to realise that we have three important departments at work, all of them of enormous importance and magnitude. The first is to carry out certain important work of national importance for the Government, the second is the supply of dyes for the immediate needs of our shareholders, and the third is the building up of a national industry for the permanent supply of dyes for this country. Our deliveries were of vital national consequence, and when you cast your thoughts back to the winter of 1915–16 and realise the extent to which the fate of our armies and of the country was dependent on such supplies, I am sure you will agree with me that this is a matter of great satisfaction. Our output during the year has been substantially increased. Now the output of colours is more than three times the amount of the pre-war amount, and when you consider that we have in addition made all

our intermediate and many of our raw materials to enable us to increase the output, I think you will agree that this is a very substantial effort to have accomplished. In addition to our own production we have continued, as far as the means of transport would allow, the supply to Swiss firms to manufacture dyes and send them back to this country, either through us or directly. The result has been that by our efforts and the efforts of other dye manufacturers the users of dyes in this country have been kept supplied not with all they would like to have, or would require in ordinary times, but sufficient to keep their works running; and I believe there has been no unemployment in practically any trade through want of supply of dyes. If you look at the situation when the company was originally formed and consider the apprehension of workpeople unable to find employment through the complete failure of dyes, I think you will agree that it is a matter on which we may congratulate ourselves that we have so far succeeded."

The chairman further added that colonies of research students had been established in different universities; the students were in the employment of British Dyes, and were acting under the guidance of Professor A. G. Perkin, at Leeds, and of Professor Robinson, at Liverpool. Research work was also constantly being carried out in the new works laboratories of British Dyes. In order to encourage the supply of chemists an offer had been made to the universities that if they will send a qualified chemist an engagement for three years will be found him at a satisfactory salary.

Speaking at a meeting held on October 31 at the Cutlers' Hall, Sheffield, Mr. D. Gambashidze, of the Russo-British Chamber of Commerce, London, said that Germany was going to make a desperate effort to secure the Russian market, and if she secured it entirely for herself she would pay any indemnity that could be imposed upon her, and within ten or fifteen years' time she would be rich enough to start another devastating war at the expense of Russia. If a free hand were given her in Russia they would be courting another disaster much worse than the present one. Some might be inclined to think it would be impossible to get into the Russian market because of the closeness of Germany. That was not a good excuse when they remembered they were only three days from Riga. Japan, the United States, and Germany were all racing for the Russian market, and very little attempt was being made by this country. One of the causes of that was that there were naturalised and some unnaturalised Germans in this country who, in the direct interests of their country, were spreading rumours about the difficulties of trading in Russia.

What was required was that they should pay attention to the credit system. It was necessary to create a middle organisation between the British manufacturer and the Russian. There were plenty of manufacturers in Russia to-day who would be willing to co-operate with British manufacturers, and who would put up more than half the capital. The resources of the country were enormous. They did not want charity in Russia; they were only asking for a business co-operation, to their mutual advantage. Unless British firms came in immediately in co-operation with Russian they would find after the war had finished that the United States had secured concessions, and there would be nothing left.

Messrs. Dick, Kerr and Co., Limited, held their ordinary general meeting in London on Wednesday, October 31. In the course of his address the chairman, Mr. C. T. Cayley, stated that, like all large employers, they were naturally following the attitude of labour itself, and they fully realised that to meet the necessities of after-the-war conditions a complete understanding and co-operation between capital and labour was both desirable and necessary. The board and management committee had confidence that all would be well in that direction, provided labour was met in a spirit recognising that an entirely new basis of relationship must be established. If the country and the Empire met the new conditions that were bound to arise after the war fairly and squarely by adopting new methods of commercial relationship, imperial and international, he thought the inter-relationship of employer and employed could safely be left to the common-sense of those directly concerned.

H.M. Trade Commissioner in New Zealand states, under date August 13, that an Act to amend the Dominion Factory Act of 1908 was passed during the last session of the New Zealand Legislature. The Act provides, *inter alia*, that an inspector of factories may require the occupier of any factory, within a time to be specified in a requisition, to provide such heating appliances as may be considered necessary. The demand for such appliances would be chiefly in the South Island in connection with newly-erected factories or buildings.

The Secretaries of the U.S. Army and Navy are civilians, owing to a Government policy that has been found consistent and wise, says *Machinery*, New York. But, unfortunately, the policy of employing civilians in charge of the production of army and navy munitions and material has not been followed. Is an army officer generally fitted by training to be the practical head of an armoury? Experience has shown that he is not. He may know everything about an army rifle and its use, but that is quite different from knowing how to organise a manufacturing plant and conduct manufacturing operations efficiently and economically. His training has seldom included practical manufacturing experience.

We hope, says the American journal, that one outcome of the present struggle will be the displacement of army and navy officers generally in charge of the production of our war material in favour of civilians who are not politicians, but who by reason of their practical experience have shown themselves competent to organise and conduct great manufacturing operations as efficiently as some of the men who have volunteered for such work at the sacrifice of their personal interests.

The American journal further adds that:—

Mr. Frank A. Scott, chairman of the War Industries Board, in replying to an attack by a well-known politician on a rifle contract awarded by the War Department, said: "The most valuable assets of the companies (to whom the contract was awarded) is their organisation, and without that the machinery would be of no use." The American concerns now engaged in manufacturing rifles, other than those that were equipped for such work when the war began, required from twelve to twenty-four months to organise their plants before they turned out a single rifle; and the process of organisation would be far more difficult now, because the mechanical executives and the equipment, especially the former, are practically unobtainable.

An award has just been issued by the Committee on Production giving a further advance of wages to all grades of workmen employed by members of the Engineering Employers' Federation.

The award is given in pursuance of an agreement between the Federation and 48 trade unions connected with the engineering and foundry trades, under the terms of which the Committee on Production may be called upon at intervals of four months (*i.e.*, February, June and October) to consider what alteration in wages is warranted by the abnormal conditions due to the war.

The previous awards of the Committee on Production under the terms of this agreement were made on March 1 and July 14, 1917, and the effect of the awards, in conjunction with previous awards given by the Committee for the several districts, was to establish for the engineering and foundry trades a general advance, as compared with pre-war rates, of not less than 15*s.* per week on time rates.

The award now issued gives a further advance of 5*s.* per week, making the aggregate increase on pre-war rates 20*s.* per week.

The award is signed by Sir David Harrel, Sir George S. Gibb, Mr. William W. Mackenzie, K.C., Mr. F. S. Button, Colonel John M. Denny, Mr. J. Duncan Elliot, Mr. William Mosses, Mr. Geo. J. Rowe, and Mr. John W. White.

With regard to the stoppage at certain of the South Wales collieries owing to a portion of the examiners and firemen not going to work on the 1st inst., the Controller of Coal Mines states that, after protracted negotiations, he obtained the consent of the Monmouthshire and South Wales Coal Owners' Association to the recognition of the Examiners' and Firemen's Union, and an agreement was reached to set up a joint board to deal with the interests of the members of the union. Owing to objection, however, on the part of the members of the union to being parties to the conditions attached to the recognition of the union, Sir Richard Redmayne, on behalf of the Controller, put forward the following formula with the object of reaching a settlement:—

"Monmouthshire and South Wales Coal Owners' Association agree to recognise the South Wales and Monmouthshire Colliery Examiners' Association. Both parties agree forthwith to set up a Joint Board. The conditions dated 16th October, 1917, form no part of this agreement, but the Coal Owners' Association informs the Examiners' Association that, if at any time the operations of the Examiners' Association should not be in accord with the conditions of the 16th October, 1917, then the recognition ceases and the question is once more open."

After separate deliberation, the owners' representatives accepted this formula, but the representatives of the Examiners' and Firemen's Union declined to do so.

Work is gradually being resumed at the South Wales collieries which had been rendered idle by the action of the examiners. The South Wales miners' ballot on the military "comb-out" question shows a very large majority against the "down-tools" policy. The latest figures are the following:—

For the "comb-out"	79,240
Against	22,215

These figures therefore show a majority of 57,025 for the "comb-out" and against the "down-tools" policy.

In continuation of his conference with the Trade Union Advisory Committee on the subject of the interpretation and application of the 12½ per cent. bonus to certain classes of skilled men in the engineering trade, the Minister of Munitions met, on the 7th inst., a sub-committee of the larger committee, consisting of Mr. Coates (United Machine Workers' Association), Mr. Davidson (Ironfounders' Society), Mr. Kaylor (Amalgamated Society of Engineers), Mr. Lindsay (Boilermakers' Society), Mr. Rowan (Electrical Trades Union).

The whole question was discussed, and the sub-committee submitted proposals, and as these would involve a consideration of certain new problems, in the circumstances it was agreed to postpone the next meeting till Wednesday, the 14th inst. It is hoped that this interval will enable the Minister, after consultation with all departments concerned, to announce a final decision upon the whole question. This delay will not involve any hardship upon any classes of men at present excluded who may subsequently be included, as under the terms of the Order their inclusion would necessarily involve retrospective payment.

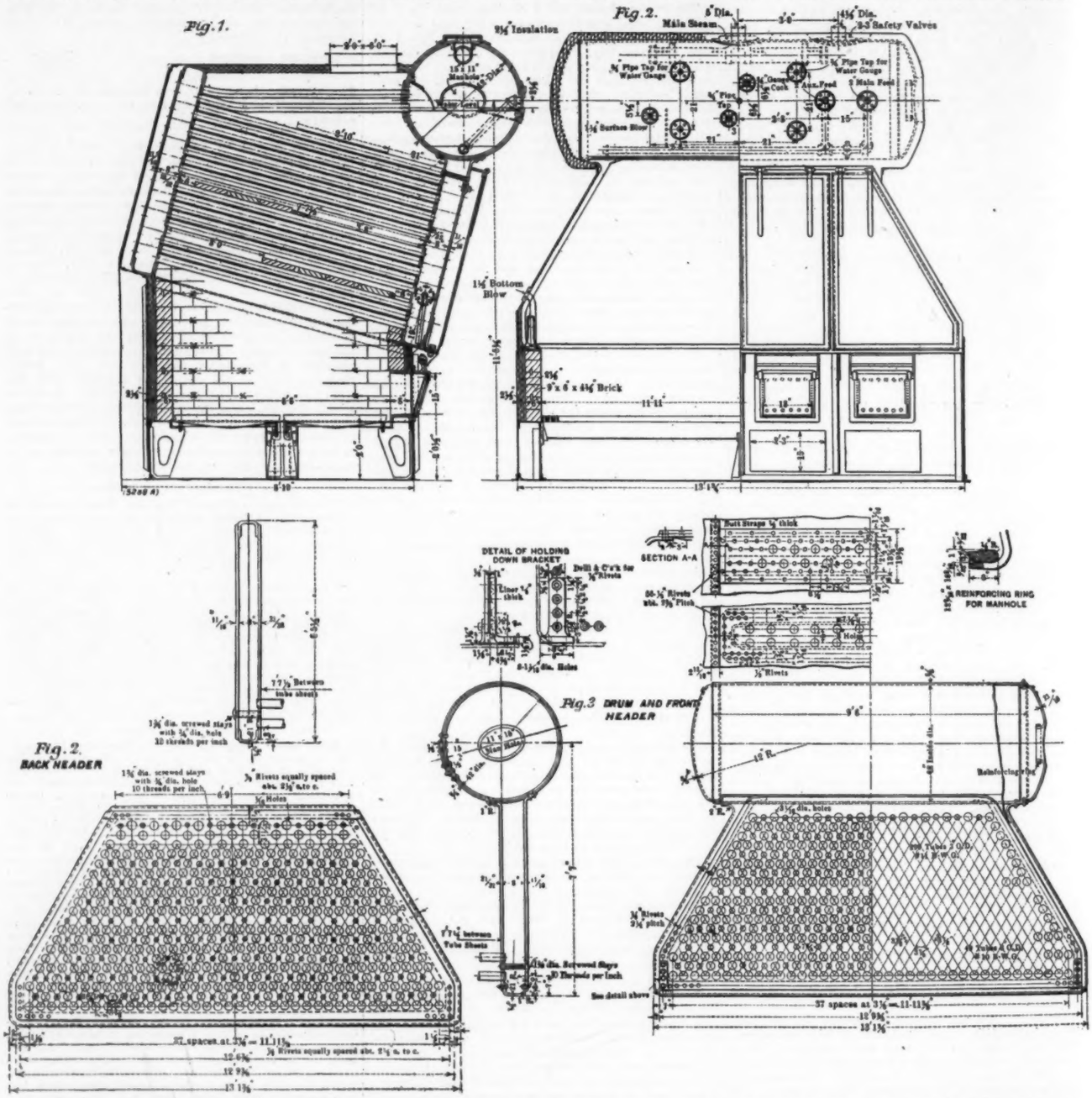
THE FEDERATION OF BRITISH INDUSTRIES.—Sir Richard Vassar Smith, chairman of Lloyds Bank, has been elected president of the Federation of British Industries for the forthcoming year, in succession to Mr. F. Dudley Docker, C.B.

INTERNATIONAL TABLE OF ATOMIC WEIGHTS.—The October number of the Journal of the Chemical Society contains a letter, signed by Sir Edward Thorpe, to the effect that the International Atomic Weights Committee has decided to intermit its annual reports owing to the fact that certain of its members are largely occupied with matters arising out of the war, that it is difficult to keep up correspondence, and that experimental work on the subject of atomic weights is practically interrupted. The table for 1917 should therefore be regarded as current for 1918.

COLOURLESS MODIFICATION OF MERCURIC IODIDE.—The mercuric iodide HgI_2 is one of the most striking examples of allotropy and dimorphism. The ordinary salt forms a scarlet-red powder or red crystals of the quadratic system. This red iodide fuses to a yellow liquid, the vapours of which condense to yellow orthorhombic crystals; the yellow crystals, however, change back into the red when heated to 126 deg. C. or when merely touched. This experiment is well known. Professor Tammann, of Göttingen, has now succeeded in preparing a third, colourless, modification of the iodide; the fact is especially interesting in so far as the iodides of zinc and cadmium, the metals which stand nearest to mercury in the periodic table, are both colourless. The colourless mercuric iodide is very unstable. Tammann obtained it by heating the red modification in a long tube to 300 deg. or 500 deg. C. and suddenly reducing the gas pressure in the tube to 0.1 atmosphere. The salt then condenses to a colourless snow, which turns pink in a few seconds, however, and red in a few minutes.

FURTHER RESTRICTIONS IN THE GERMAN IRON INDUSTRY.—The decree of July 7, according to which bar iron, sections and Monier iron were put under restriction and their use for building purposes, subject to certain exception, prohibited, has now been followed by a fresh decree, which not only refers to the aforesaid specialities, but also comprises steel plates, steel and iron tubes, and diverse kinds of castings. The prohibition against use for building purposes of all the goods under restriction has been extended to all works installations of all kinds and in all branches, especially power plant, machine tool works, transport, sanitary appliances, &c. The prohibition does not apply to goods of the above description which on the date of the decree, which came into operation on October 18, are in the possession of a finishing manufacturer or a consumer, also such goods which before September 25 have been ordered from an intermediate party and are delivered before November 18. Use of the restricted goods can in exceptional cases be granted for the construction of factory installations, &c., such permission to be given by the Metal Distribution Bureau at the instance of the war ministry, a copy of the application to be sent to the local military bureau. In cases of export the permission is granted by the Imperial Commissioner for export and import licenses. No permission is necessary in cases of repairs of existing concerns when the monthly consumption does not exceed 400 lb. The military and police authorities have the right to inspect the books, the correspondence, works and premises of the concerns in question.

STANDARD WATER-TUBE BOILERS FOR U.S. EMERGENCY WOODEN STEAMSHIPS.



THE boilers for the standard wooden steamships of 3,500 tons deadweight carrying capacity which are being built for the United States emergency fleet will be of the marine water-tube cross-drum type, with straight tubes expanded into continuous-stayed steel plate headers, and of these we reproduce, on this page, sectional drawings from *International Marine Engineering*.

The boiler has been designed by the United States Shipping Board Emergency Fleet Corporation, which has charge of the building of the ships for the Shipping Board, with a view of providing a simplified type of boiler composed of small parts which can be manufactured in large quantities with the utmost rapidity by practically any boiler shop in the country, wherever it may be located. The urgent need of getting the greatest possible number of cargo vessels into commission as quickly as possible to offset the destruction of merchant ships by German submarines, made imperative the adoption of a type of boiler that can be constructed by any boiler shop with its ordinary facilities and without the necessity of providing special machinery or equipment. It was necessary, also, that the boiler be of such type that it could readily be dismantled after construction and shipped from points inland to the seaboard.

As stated above, the boiler is of the cross-drum type, with straight tubes expanded into continuous stayed steel plate headers. The height to the centre of the steam drum is 11 ft. 5½ in.; the width of the furnace front 13 ft. 4¾ in., and the depth from the furnace front to the back of casing 8 ft. 10 in. The grates are 6 ft. 6 in. long by 11 ft. 11 in. wide, giving a grate area of 77.45 sq. ft. The total heating surface is 2,544 sq. ft., making a ratio of heating surface to grate area of 33 to 1.

The heating surface is distributed as follows: tubes, 2,452 sq. ft.; front header, 33 sq. ft.; back header, 38 sq. ft.; drum, 21 sq. ft. The tubes, of which there are 414 in all, are hot-rolled, seamless steel, 3 in. outside diameter, of No. 11 B.W.G., except the three bottom rows, which are No. 10 B.W.G. All of the tubes are straight except the two top rows, which are bent to a 36-in. radius near the back header.

The steam drum is 42 in. inside diameter, with bumped heads, one of which is solid, ¾ in. thick, and the other 1⅛ in. thick, with a 11-in. by 15-in. manhole. The back header is stayed with 1¾-in. hollow staybolts and the front header with 1¾-in. solid staybolts.

The boiler is designed for a working pressure of 200 lb. gauge, and a hydrostatic pressure of 400 lb. gauge. It will be fitted with a system of forced draught and is designed to evaporate 15,000 lb. of water per hour, with feed water at 200 deg. F. when burning about 20 lb. of anthracite coal per square foot of grate. The specifications embody the latest rules and regulations of the United States Steamboat Inspection Service applying to marine water-tube boilers for ocean and coastwise trade, and the design has been approved by the Board of Supervising Inspectors and by the American Bureau of Shipping. No punching will be allowed on inside plates. All drilling and reaming for rivet holes shall be done from the outside after the plates are assembled. The use of drift pins will not be allowed. "Bulled" rivets are specified where possible, and they must be driven at a cherry-red heat and held in the riveting machine at least 30 seconds.

The furnace is constructed of steel plates and angles designed to be readily dismantled for shipment. The fire-box and casing part along a plane parallel to the inclination of the tubes and are so formed as to provide a support for the lower part of the front and back headers, as shown on the drawings.

The furnace is lined with special firebricks, 9 in. by 6 in. by 4½ in., having continuous grooves on one end

to receive ⅝-in. square headbolts for fastening to the casing. These grooves are to be completely filled with high-pressure cement, and a thin coating of the same cement will be interposed between butts and successive layers of firebricks.

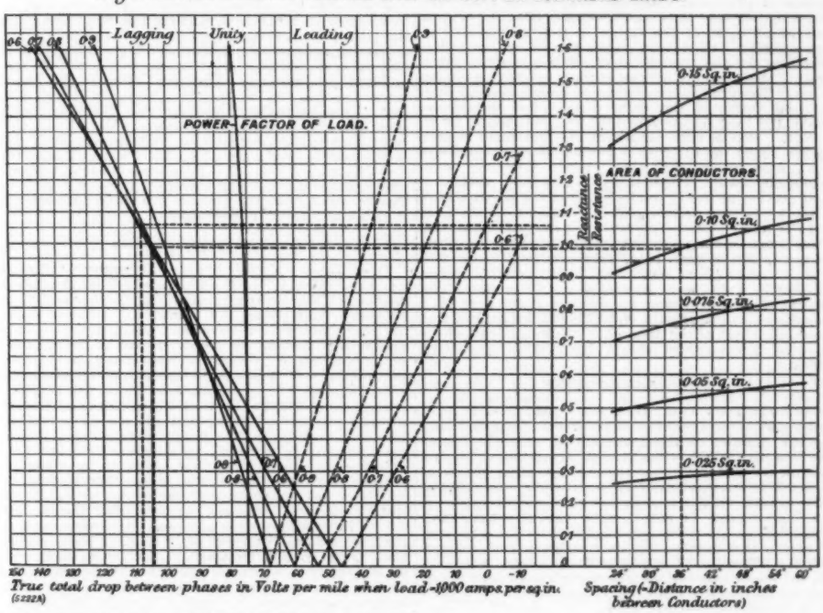
The ash pan is built up of steel plates made in sections for easy removal. The edges of the plates are flanged for bolting together.

PRESSURE DROP CURVES FOR COPPER OVERHEAD LINES.*

By G. N. Wright, Associate Member.

Explanatory Note.—The accompanying curves (Fig. 1) were drawn so that the true pressure drop (*i.e.*, the difference between the voltage at the generating end and the voltage at the receiving end) on a three-phase 40-period overhead line at any load could be found readily and without complicated calculations. By working out numerous examples it has been proved that though these curves were drawn for a 3,000-volt line two miles long with conductors symmetrically arranged and loaded to 1,000 amperes per square inch, the error for other commercial lengths and loading of line and other voltages is quite negligible—in fact, greater inaccuracy might be expected in taking a reading from the curve itself. The true drop when the load is other than 1,000 amperes per square inch may be found by simple proportion.

Fig. 1. CURVES SHOWING VOLTAGE DROP ON COPPER OVERHEAD LINES.



The curves will be found to be absolutely correct for a 3,000-volt line two miles long, or an 11,000-volt line $2 \times 11{,}000 \div 3{,}000 = 7\frac{1}{3}$ miles long, or a 20,000-volt line $2 \times 20{,}000 \div 3{,}000 = 13\frac{1}{3}$ miles long, or a 440-volt line $2 \times 440 \div 3{,}000 = 0.3$ mile long, loaded to 1,000 amperes per square inch; or for double these lengths loaded only to 500 amperes per square inch, or for half these lengths loaded to 2,000 amperes per square inch. Where the length of line is less or the current density lower, the curve reading will be slightly high, and, conversely, when the length of line is greater or the current density higher the curve reading will be slightly low; but, as mentioned above, the error is negligible, being less than 1 per cent. for any commercial proposition.

Alfred Hay's formula for inductance was used in the calculations, namely, inductance per mile of single-phase line in henries $= 14.8 \times 10^{-4} \log_{10} (d/r)$. Capacity has been disregarded as negligible, it being assumed that the curves will not be used for voltages higher than those likely to be adopted in this country. Besides being useful for calculations of voltage drops, the curves bring clearly to light the fact that though smaller conductors give higher inductance than larger ones for the same spacing, the ratio of reactance to resistance for small conductors is less, and therefore the actual drop is less at the same loading per square inch for loads with lagging power factors.

To make the curves of more general use, the following particulars for conductors in the same plane, for single-phase lines, and for split-conductor lines have been added, and also those for other frequencies, though the curve does not allow for skin effect, which would be present at very high frequencies:—

If the line under consideration has conductors arranged in the same plane, a point 7 per cent. higher should be taken on the reactance/resistance line before looking across to the left. If the line is a single-phase one, 15 per cent. should be added to the drop obtained from the curves. If the periodicity is other than 40 a new point should be taken on the reactance/resistance line corresponding to the original reading multiplied by (new periodicity/40) before looking across to the left. If the line under consideration has aluminium conductors a new point should be taken on the reactance/resistance line corresponding to the original reading multiplied by 0.6 before looking across to the left, and the drop obtained should be multiplied by 1.66.

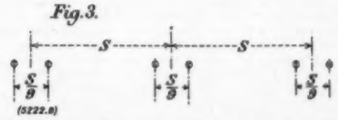
It may be seen from the curves that in comparing a copper line with an aluminium line, the latter having conductors of equal conductivity to the conductors on the former, the true drop for the same load at the same power factor* is less for the aluminium line than for the copper line if the spacing is the same in both cases, but if the spacing of the aluminium conductors has to be increased on account of the greater sag, this almost exactly neutralises the saving.

If the line under consideration is a split-conductor one with conductors arranged as shown in Fig. 2, consider one circuit only (the drop on the other circuit will naturally be the same), and after finding the point on the reactance/resistance line corresponding to the size of conductor and spacing, add 7 per cent. on account of conductors being in the same plane, and to this new figure add 6 per cent. (this covers the effect of mutual inductance between circuits) before looking across to the left.

If the line under consideration is a split-conductor one with conductors arranged as shown in Fig. 3, consider one circuit only as before, and after finding the point on the reactance/resistance line corresponding to the size of conductor and spacing, add 7 per cent. on account of conductors being in the same plane, and to this new figure add 40 per cent. (this covers the effect of mutual inductance between circuits) before looking across to the left. The percentages are average figures, as they vary slightly with different spacings and sizes of conductors, but when used for any commercial proposition the error, if any, is very slight and may be considered negligible. It may be seen from the above that the pressure drop on a split-conductor line is considerably less than that on a single-circuit line having conductors of double the area and carrying the same load if this load is at a lagging power factor.

Fig. 2

Fig. 3.



To ascertain the short-circuit current of any three-phase line (*i.e.*, the current which would momentarily flow if the three phases were dead short-circuited at the receiving end and the voltage at the generating end was kept constant), let

a = value of reactance/resistance for this line as obtained from the curve.

b = length of the line in miles.

c = area of each conductor in square inches.

d = voltage at generating end.

Then, short-circuit current in amperes

$$= \frac{d \times c \times 40}{b \times \sqrt{(1 + a^2)} \times 3}.$$

If the short-circuit current of a single-phase line is required, or if only two of the three phases are short-circuited, the above formula may be used, but 13 per cent. must be deducted from the result obtained.

Incidentally the points where the lines giving the power factor of the load intersect the line for which

$$\frac{\text{reactance}}{\text{resistance}} = 0$$

give approximately the true pressure drop between phases per mile on a three-core cable when the conductors are loaded to 1,000 amperes per square inch, and the approximate true drops for other lengths and loading may be found by simple proportion. No allowance for capacity is made, but the capacity current in most cables makes very little difference to the actual drop. The results given by the curve are of course the more correct the lower the voltage at which the cable is working and the heavier the amperes per square inch per conductor.

* Paper read before the Institution of Electrical Engineers.

* When this power factor is a lagging one.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting held on October 26, at the Imperial College of Science, Mr. W. R. Cooper, M.A., vice-president, in the chair, a paper entitled "On a Class of Multiple Thin Objectives" was read by Mr. T. Smith, B.A. The objectives dealt with are cemented combinations of several thin lenses. Two kinds of glass only are employed, the odd elements being of one kind, say, crown, and the even elements of the other kind, flint. Such lenses may be regarded as combinations of achromatic cemented doublets, and formulæ are found for the aberration coefficients of such lenses in terms of those of a standard doublet when the geometrical conditions for the absence of air-gaps between the components are satisfied. Generally speaking, the results reached are that the outer surfaces are concerned with coma, and the internal surfaces with spherical aberration. In all cases the determination of a system to satisfy given conditions involves only the solution of a quadratic equation, and an algebraic method thus effects a solution in a fraction of the time involved in a trigonometrical investigation. Chromatic differences of first order aberrations are easily determined.

The application of the method is illustrated by a series of quadruple objectives which satisfy the ordinary conditions for telescope objectives. Diagrams show the variation of the curvatures with the different forms, the magnitude of the second order spherical aberration, and the chromatic differences of first order aberrations.

In the discussion Professor J. W. Nicholson congratulated the author on the increased simplicity which he had brought to some of these important problems. He thought a good case had been made out for the further numerical investigation of this type of objective, and hoped the author would let the society have the results of such an investigation soon.

Professor A. E. Conrady (in a communication which was read by the secretary) said that the paper could not be regarded as of much practical value. No practical optician would think of constructing a telescope objective of four or more cemented components; even a triple objective is avoided whenever possible, as the technical difficulties are very serious when there are several cemented faces in a lens of considerable size; and he could not conceive of the necessity of such complication ever arising in small lenses for telescopes.

Mr. T. Smith said a very great deal of work would be involved in a systematic exploration of the properties of multiple lenses over the possible range of optical glasses, and the publication of such an extension could not be expected in a short time. He did not quite understand Professor Conrady's point of view, which would be most deplorable if it were generally adopted by the optical industry, for it could only lead to utter stagnation. Obviously there were always difficulties in making a complex rather than a simple instrument; but difficulties must not be allowed to retard progress, and no investigation should be starved out because of them. Unless investigations were made it was impossible to say whether the advantages they might show were sufficient to compensate the attendant disadvantages. As a matter of fact, the question of employing quadruple objectives had actually arisen as a practical proposition in an instrument designed by a practical optician. In the particular case the optical conditions turned out to be unfavourable to the use of such a lens. Had it been otherwise there was no doubt it would have been employed, and any technical difficulties—which were not regarded as a deciding factor—would without doubt have been overcome. In Germany certainly, and in this country also, he believed, quadruple and even quintuple cemented objectives had been made.

A paper on "The Radius of the Electron and the Nuclear Structure of Atoms" was read by Professor J. W. Nicholson, M.A., D.Sc., F.R.S.

The electron is usually regarded as a globule of electricity with a definite radius. This conception has proved valuable, but involves difficulties in connection with the nuclear structure of complex atoms. On the view that the electron consists of a region of strain in the ether such line constants should have some significance throughout the whole ether; which may, in fact, be in some manner cellular with these linear magnitudes involved in the specification of the cells, and therefore in any strained structure composed of them.

The electron would be regarded as a state of strain

which for practical purposes is concentrated at its centre, rapidly diminishing outwards according to some very convergent law involving some line constant in its specification. By way of illustration the idea is worked out mathematically on the assumption that the strain varies as $e^{-\lambda r}$, on which hypothesis λ^{-1} is the "radius." It can be shown that the Lorentz formula for mass as a function of velocity can be obtained for this type of electron. The charge on the electron is regarded as a fundamental property of the ether, and is related to Planck's constant h.

In the discussion Dr. H. S. Allen said there could be little doubt of the existence of a relation, referred to by Professor Nicholson, between Planck's constant h and the charge of an electron e. The relation suggested by Lewis and Adams might be written—

$$c\,h = \sqrt[3]{\frac{5\,\pi^5}{15}}\,(4\,\pi\,e)^2,$$

where c was the velocity of light. Taking Millikan's latest value for e (4.774×10^{-10}) and $c = 3 + 10^{10}$, we find $h = 6.558 \times 10^{-27}$. From his photo-electric experiments Millikan found $h = 6.57 \times 10^{-27}$ within about 0.5 per cent., and in his latest table of fundamental constants he gave $h = (6.547 \pm 0.013) \times 10^{-27}$. Thus the agreement was within the limits of experimental error. All the principal radiation constants could be expressed in terms of e. The curious numerical relations between the primary constants of physics, to which attention was directed in his paper read before the society in 1915, depended upon the above formula connecting h and e. On the lines suggested in Professor Nicholson's paper it would seem as if most, if not all, of the important constants of Nature might be referred to some fundamental property of the æther.

Sir Oliver Lodge wrote: I am much interested in Professor Nicholson's ingenious plan for doing away with the definite boundary of an electron, and devising a mathematical scheme which shall enable us to regard it as a point-centre of strain decreasing exponentially in every direction without limit, so that the linear dimension associated with it shall be—like many time constants—the distance at which the density is reduced to $\frac{1}{e}$ th of what it is at the centre. This plan, if it can be developed properly, seems to get over many of the difficulties about the coherence of parts of a charge, and about the extraordinary properties of a nucleus, which though, from some points of view, an extremely small and highly-charged unit, yet necessarily has a complexity which enables it to be disintegrated and fired off in fragments. The ready permeability or inter-penetrability without destruction of Professor Nicholson's conception of an electric unit seems likely to diminish the difficulty of conceiving such a nucleus; and on the whole his suggestions seem to me helpful and valuable. I do not feel justified in saying more at the present time.

Professor Nicholson, in reply, said it was of interest to see that Millikan's final value of h was practically equal to the first value that had been obtained for that constant.

Small Open-Hearth Furnaces.—The McLain-Carter small open-hearth furnaces, says *The Iron Age*, New York, are built in sizes ranging from 1 ton to 5 tons. Oil fuel is used. The oil consumption is stated to be 65 gallons to 70 gallons per ton of steel. The roof, it is claimed, will stand for 500 to 700 heats, with the furnace turning out high-temperature, fluid metal.

Increased Railway Rates in Norway and Sweden.—A very substantial temporary increase in the rates on the Norwegian State Railways, both for passenger and goods traffic, has just been decided upon owing to the very material increase in the cost of running the railways. Including previous, temporary increases in the railway rates, the rise amounts to 80 per cent. for first and second-class passengers, 60 per cent. for third-class passengers, 100 per cent. on passengers' luggage, and 100 per cent. on express and ordinary goods traffic, except articles of food, feeding-stuff, manure and fuel, for which commodities the increase amounts to 70 per cent., and milk, for which it is 50 per cent. It is understood, that these prices will be revised when more normal conditions again prevail. In Sweden a further increase of 50 per cent. on goods traffic is proposed, making the increase since the beginning of the war 100 per cent.

Special Entry for Royal Naval Cadetships.—About fifty cadetships (special entry) will be offered for competition at the examination to be held by the Civil Service Commissioners conjointly with the Army Entrance Examination for Woolwich and Sandhurst, commencing on March 5 next. Candidates are required to be not more than 18½ nor less than 17½ years of age on December 1, 1917. Candidates who competed unsuccessfully at the examinations in July and November, 1917, and are still eligible as regards age, will be allowed a further opportunity to compete. Candidates who have served with His Majesty's naval or military forces will be allowed a deduction from actual age in respect of such service. To receive this concession, candidates must furnish an official certificate as to the period of their service. The syllabus of subjects of examination and further particulars may be obtained from the Secretary of the Admiralty, Whitehall, S.W. Forms of application to be filled in by the parents or guardians of candidates will be furnished on application by letter addressed to the Secretary of the Admiralty. The forms should be completed and returned to the Secretary of the Admiralty not later than January 1, 1918.

LIGHT AND ELECTRICITY FROM WASTE GAS.

The production of lighting gas from the coking process and the generation of electric energy from the surplus of the blast-furnace and coke-oven gases has increased very materially at the Rhenish-Westphalian mines of late years. In the year 1903 the first move in this direction was made by two mines in the Dortmund district, the König Ludwig and the Prosper I mines, where lighting gas was produced at the coke ovens. In addition, there were two other mining gas works, those of Shamrock III and Wilhelmina Victoria. The aggregate gas production from these four concerns in 1903 amounted to only 44,500,800 cub. ft. In the year 1906 the Deutscher Kaiser concern took up gas manufacture, and is now at the head of the list in this connection, and during the next few years a number of other mines followed the example; in the year 1908 the Sälzer-Neucek mine alone produced over 176,000,000 cub. ft. of gas. In the year 1914 the aggregate production of lighting gas from the furnaces in the Ruhr district amounted to more than 5,600,000,000 cub. ft., against 4,200,000,000 cub. ft. in 1912 and 1,560,000,000 cub. ft. in 1910. In the year 1914, 23 mines had gone in for gas manufacture. This rapid increase in the production of lighting gas from the furnaces is in the first attributable to the construction of long-distance pipe lines, whereby many towns, some outside the industrial district proper, found it advantageous to discontinue their own production of gas and, instead, draw their supplies from the furnace gas. In this connection the Deutscher Kaiser concern is particularly to the fore, in the year 1914 producing no less than 1,400,000,000 cub. ft. of gas, from which most of the towns in the mining district were supplied. Coke-oven gas is also on an increasing scale used for the production of electric energy, either through the medium of gas engines or as fuel under boilers. The production of electric energy at the mines and iron works of the Ruhr district has risen from 566,000,000 kw.h. in the year 1909 to 1,689,000,000 kw.h. in 1914. Also in this connection the Deutscher Kaiser concern heads the list with a production of 210,000,000 kw.h., next comes the large Phönix Company with 210,000,000 kw.h. These two concerns only produce a small portion of the electric energy at the mines themselves, by far the greater part is generated at the iron works or other places. The reverse is the case with most of the other mining concerns, thus the Gelsenkischen Company, in the year 1914, only produced 33,000,000 kw.h. at their iron works and other works, whilst 131,500,000 kw.h. were generated at the mines. The disposal of electric current to outsiders in the year 1914 amounted to an aggregate of 66,000,000 kw.h., but this figure falls short of the amount of electric energy which the mining companies obtain from other electricity works.

Canadian Iron and Steel Production.—The total production of steel ingots and castings in Canada in the first six months of the current year amounted, says *The Iron Age*, to 836,149 short tons, an increase of 246,596 tons, or 42 per cent., over the corresponding period of 1916. The average monthly production was 139,358 tons, against 98,259 tons in the first half of 1916. A new high record in output was reached during May of 155,346 tons, but the June figure showed a falling-off of about 18,000 tons. Pig-iron output, from returns covering all producers, was 586,998 short tons, as against 562,097 short tons for the corresponding six months of last year. Imports from the United States have been on a considerably larger scale. The imports of steel ingots and castings for the first six months of this year amounted to 139,640 short tons, against 47,493 short tons for the same period of 1916. In pig-iron the increase was from 29,801 tons last year to 38,858 tons for the present year.

Institution of Naval Architects Scholarship in Naval Architecture.—A scholarship designated the "Institution of Naval Architects Scholarship in Naval Architecture" will be offered for competition among students of the Institution in 1918. All students (being British subjects) who have been elected at or before the annual general meeting of the Institution (March 20, 1918) will be eligible for this scholarship. The scholarship is of the annual value of 100*l.*, and is tenable for three years. Candidates are not to be less than 18 nor more than 21 years of age on March 1, 1918, and must at that date have been continuously employed for at least two years upon naval architecture or marine engineering. Temporary regulation during the war: In cases where candidates have been prevented, owing to war service, from entering for the scholarship, an extension of the age limit—not exceeding 18 months—may be allowed by the council on satisfactory evidence being produced by the candidate that his studies have been interrupted by war work. The scholarship will be awarded in connection with the competitive examinations for scholarships, studentships, &c., to be held by the Board of Education in April and May, 1918, in the following subjects: (1) Naval architecture; (2) pure mathematics; (3) applied mechanics (materials and structures); (4) Either (*a*) applied mechanics (machines and hydraulics), or (*b*) heat engines. A prize of books or instruments to the value of 5*l.*, offered by the Earl of Durham, will be awarded by the council to the candidate next in order of merit to the winner of the scholarship or to such other competitor as, in the opinion of the council, may deserve the award. All communications with respect to the scholarship should be addressed to the Secretary of the Institution of Naval Architects, 5, Adelphi-terrace, London, W.C. 2.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—The conditions of briskness and activity which have held now these many months continue to increase daily, and every rolling mill in the West of Scotland is kept busily employed turning out the enormous quantities of finished steel material required for shipbuilding, munitions and other purposes directly connected with the war, particularly as plates and high-tensile steel bars are in as keen demand as they have been at any period during the past three years. Government control is insistent, and private business is of next to no account and receives not the slightest consideration. Some small shipments to France and Italy represent the entire export of steel at the moment. Prices are firm and likely to increase shortly, owing to the recent advance in the cost of coal, although, as things go, steel plates at 15*l.* or so per ton are absolutely reasonable were it possible for anything like immediate delivery to be guaranteed.

Malleable Iron Trade.—Makers of malleable iron continue to be pressed on every side for heavy deliveries of their products, both iron and steel, the entire output being required, either directly or indirectly, for work of national importance, no other orders being considered meantime. Export is very flat, the only material which is being allowed to leave the country at present is that which is necessary for agricultural work and mining operations. Orders are well booked up and rates are decidedly stiff, the increased cost of coal being a most important factor.

Scotch Pig-Iron Trade.—Practically no change has taken place in connection with the pig-iron trade during the past week, the continued scarcity of certain brands militating against any further developments meantime, although, of course, a most extensive amount of work is being put through. The local steel works absorb every possible ton of hematite, while as much forge iron as can be produced goes at once to the iron works employed on Government contracts. Very little work other than that on national account is being dealt with at the present, and prices for export have all advanced about 2*s.* 6*d.* per ton. It is fully expected that a definite pronouncement regarding increased rates will be made shortly, the rise in the price of coal making something of this kind absolutely necessary.

The Hong-Kong Steel Foundry Company, Limited.—Mr. A. G. Gordon presided at the annual meeting of this company, says *The London and China Telegraph*, and stated the following: "Orders during the year under review have been plentiful, and to meet the growing demand for a heavier class of work offered we have arranged to begin, without delay, to lay down two more sets of patent radio furnaces, and contemplate, later, building two extra furnaces, which will enable us to accept urgent orders for work which cannot be executed without considerable delay and expense to our clients. This will also enable the company to make soft ingot steel for forging purposes to take the place of home orders which cannot be fulfilled, owing to the difficulties of transport and Government restriction against the export of steel material from the British ports. If this state of affairs continues, we may still increase our output by making further additions to the plant, to meet the urgent demand for soft ingot steel. The encouragement given to this company to further its endeavours to supply the wants of its present customers has caused your managers, with the sanction of the shareholders, to increase its capital to 1,000,000 dols. A scheme is already in hand for its reconstruction under a board of directors, which will be fully explained to the public later, when it is hoped the extra capital will be forthcoming to enable the company to proceed with an installation to meet all further requirements. As for China, and its awakening, about which so much has been written, we feel that when the war is over things will begin to move. Even during the last three years, while Europe has been locked in a death struggle, China has not remained stationary. A survey is in progress for a line which will certainly develop portions of the country through which flows the West River and give a stimulus to trade in Kwangsi, where, it is known, there are deposits of coal and iron, as well as of tin and antimony. I am not, therefore, pessimistic as to the future of Kwangsi or Kwangtung if the authorities will only encourage local enterprise. Recent events have shown that in Canton there is a desire to stimulate the development of mineral enterprises in the province, and I feel sure the day is not far distant when coal and iron will be shipped to Hong Kong in large quantities. We have been inundated with offers to supply us with iron ore and other minerals. An article in one of the local papers some time ago dealt with the question of manufacture in Hong-Kong of Munitions of War, and said that much effective help could doubtless be given to the cause of the Allies if arrangements were made for such manufacture here. The article stated that persons in important positions had said that no means existed in Hong-Kong for the manufacture of steel shells, but the fact is apparently not known to these persons that there does exist, and did exist at that time, a foundry in the colony capable of turning out what was precisely required; and doubtless it will interest the patriotic Hong-Kong public to know that this company was asked by the Government, on behalf of Russia, if its resources could be made available for the supply of munitions of war, and a reply was sent to the effect that its resources were such that at the time 3 tons in cast steel shells or ingots for making shells could be supplied each day, and that, if required, additional plant could be procured in four or five months to supply 45 tons a day guaranteed.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The position has undergone little in the shape of a vital change, though supplies are harder to get. The reserves at the pits are smaller than have been known for some time, and there is nothing to spare for open-market business. Works, railways and blast-furnaces have systematically built up fairly substantial stocks for winter workings, but have not now much prospect of adding to them. A limited shipping tonnage is passing for Allied Powers, France and Italy taking larger shipments, whilst the neutral trade falls away gradually. No surpluses are available after the contract orders for gas companies have been executed. Cokes are still at top values. The household position continues to find the demand in excess of the traders' abilities to cater for it, and arrears mount up to-day as a matter of course. The new regulations regarding the quantity of coal which any household may stock at a given time is having some effect in securing better distribution. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* 6*d.* to 15*s.*; seconds, 13*s.* to 13*s.* 6*d.*; and smalls, 9*s.* to 10*s.* per ton at the pit.

Iron and Steel.—The market for raw materials is unsettled by the uncertainty regarding the maxima of prices. It is taken as a matter of course in some quarters that the rise in the tariff will take place, and producers are making it a condition of all business that they shall have the benefit of any advance that may be conceded during the running of the contracts. With the general position affected by these conditions it is not surprising to find that the business done is not on so large a scale as has been the case for some time past. Consumers, where their stocks are such as they can afford, are holding their hands for a time to see how the matter settles itself, and there is not the tension of the days when the demand was far and away in excess of the supply. Basic sorts continue to arrive with greater freedom, but there seems to be a corresponding falling-off in the tonnage of both forge and foundry, which suggests that the basic sorts are being expanded at their expense. Steel works are running at their top bent, and as they are getting supplies of base material with a certain amount of regularity there is considerable progress made in the matter of production. So far the American intervention has not lightened the labours of local firms to the extent anticipated, if at all, but there is a confident feeling that something of a very definite character will be heard of this question before much time passes. Sheffield supplies of marine steel are maintained on the very extensive scale which the occasion demands. Aeroplane specifications are hard to keep up with, for they are constantly growing more and more exacting, and even with the aid of the electric furnaces there is some difficulty in keeping pace with contracts. Time and again domestic work has had to give way, and now more elbow room is wanted for war work. Manufacturers are resigning themselves to the inevitable, though in one of the lighter and less important trades, that of cutlery, there is some fighting to retain overseas custom. Large orders are constantly arriving from the British Colonies, whilst the inquiry for stainless steel must excite the envy of the cutlery firms, who now find this commodity unobtainable.

Trade Matters.—Sheffield has given birth to a new labour movement which may have far-reaching consequences. The Ministry of Munitions, in their recent award of 12½ per cent. to the skilled men, such as the fitters and turners, excluded sundry engineering trades, as well as the whole of the labourers. The bonus was given in the spirit of compensation to the skilled men for the loss of the greater proportion of repetition work by the dilution of labour. No sooner had the skilled men got the concession than the semi-skilled and unskilled labourers in the heavy industries were up in arms and demanded, not a 12½ per cent., but 7*s.*, which is the figure 12½ per cent. on the rates of the higher-paid workers represents. Other parties also announced that they were aggrieved, and now we have the fusion of the interests of labourers and semi-skilled workers with tool makers, pattern makers, united machine workers, steam-engine makers, core makers, iron and steel dressers, smiths and strikers, clerks, carpenters and joiners, wood-cutting machinists, and general and winding engineers. These sections have this week sent in a joint ultimatum to the Ministry of Munitions for the advance, and next Sunday will, together, consider the reply. They contend that all should be treated alike. The significance of the movement lies in the fact that for once the skilled and unskilled in this district, representing about 70,000 men at the least, are moving in unison. It is regarded as the forerunner of an important change in the local labour movement and a blow at sectionalism.

University Department of Refractory Materials—An important development has taken place in Sheffield by the establishment at the university of a department of refractory materials in conjunction with the local movement for the manufacture of siliceous refractories. For some time past efforts have been made firmly to establish the manufacture in this area of these materials for furnace linings, and it is now stated that there is every prospect of a superior type of refractory being obtained. It will be remembered that for a very long time this trade was largely in the hands of German firms, and the Sheffield movement has been promoted not merely to capture the British trade from the Germans, but to compete with them in other markets as well. Mr. W. I. Rees, F.I.C., formerly chief chemist at Messrs. Chance Brothers, Limited, Birmingham, will act as research chemist. As the movement has the solid support of the steel manufacturers, the Silica Firebrick Association, the Ground Ganister Association, and other interested parties, its success should be assured.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is quiet, as was to be expected after the recent heavy buying under the very liberal November allocations, but marked firmness continues to characterise the market. Opinion still differs as to whether quotations will be advanced as a result of increased cost of production due to the recent rise in coke, or whether the position will be adjusted in another way. Shortage of trucks impedes deliveries to no small extent, and in fact some makers, for lack of wagons, are having to put iron into stock. Export trade is small. Fairly good shipments to France are going forward through official channels. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge all stand at 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; and for shipment to the Allies No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant stores remains at 887 tons.

Hematite Iron.—No new feature of moment is noticeable in East Coast hematite iron. Demand is unabated and the promised relief by increase in the production of basic iron will be welcomed. Home consumers' minimum needs continue to be adequately met, but the margin is narrow. Quantities shipped to France through official channels are not known, but the surplus disposable for other quarters is very limited. Exports to Italy are still delayed pending the issue of September allotments, and further delay is not unexpected in view of the condition of affairs at that country. Quotations for Nos. 1, 2 and 3 remain at 122*s.* 6*d.* for home use and 141*s.* for export to the Allies.

Coke.—Heavy demand for coke for local consumption is met by very ample supply. Average blast-furnace quality is selling at 33*s.* at the ovens.

Foreign Ore.—Supplies of foreign ore are coming to hand well, and every effort is made to facilitate berthing and discharging of steamers, whilst the Control Committee arrange distribution according to needs of consumers.

Manufactured Iron and Steel.—Little news of importance is ascertainable as to the various branches of the manufactured iron and steel industries. Ordinary commercial business is virtually at a standstill, practically the whole of the production being required for Government purposes and for the shipyards. To home customers the following are among the principal market rates:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.* 10*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars, 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 15*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* For export, nominal quotations are: Common iron bars, 15*l.*; steel ship plates, 13*l.* 10*s.* and upward; steel ship angles, 11*l.* 2*s.* 6*d.*; iron ship angles, 15*l.*; steel strip, 17*l.*; and heavy steel rails, 11*l.* 5*s.*

Iron and Steel Shipments.—The shipments of pig-iron from the port of Middlesbrough during October amounted to only 23,412 tons, as compared with 45,384 tons for the previous month and 59,083 tons in August. Clearances of manufactured iron and steel showed considerable increase, rising from 8,145 tons in September to 31,365 tons in October, an increase of no less than 23,220 tons. The August despatches were returned at 24,380 tons. The aggregate shipments of pig-iron, manufactured iron and steel for October were 60,777 tons, as against 53,529 tons in September and 83,463 tons in August.

THE SHORTAGE OF RAW MATERIALS.—It has been decided in Denmark that from November 1 no petroleum whatever will be supplied for motors and for technical purposes. For lighting in private houses a minimum, perhaps, in many cases, only one-fifteenth or less of the regular consumption, is supplied, at prices which have now risen to three to four times the normal. In Norway the authorities have urged coasting steamers to reduce their speed from 12 knots to 9 knots. These are only two examples chosen at random among many.

THE SPITZBERGEN COALFIELDS.—The news of the Swedish coal-mining work at Spitzbergen remains encouraging, and it has been decided to increase the capital of the Swedish Spitzbergen company from 2,500,000 kronor to 5,000,000 kronor. The capacity of the coalfields in question seems to be exceedingly great, even allowing for exaggeration in some of the figures given. The so-called Braganza district is calculated to contain at least 340,000,000 tons of coal, at the Pyramide mountain the capacity is estimated at 380,000,000 tons, and at Bünzow's Land at no less than 3,000,000,000 tons. In any case the extent of the deposits seems much greater than was at one time anticipated. The work at Spitzbergen is being pushed forward, and the building of the comparatively long railway from the coalfields to the ice-free harbour at Bell Sound has already commenced.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The colliery examiners who struck work the previous Thursday resumed work on Monday. Only eight collieries continued idle on Monday, but this was due to misunderstandings, and by Tuesday all were at work. As the result of the interruption of operations in the coalfield, the depletion of stocks has been very considerable, and has relieved the situation not only as regards large but also small coal. In ordinary times these effects would also have been accompanied by a rise in current prices, but with values scheduled by the Controller of Coal Mines the price element is now eliminated for the market. Business has been conducted within very restricted limits. The pressure has been chiefly for coal for inland consumption, with enquiries for manufacturing purposes predominating.

Newport.—The fact that the examiners' strike was more general in the eastern and western valleys of Monmouthshire than it was in the Cardiff district explains why, relatively, the reduction in the quantity of coal standing on the various sidings has been proportionately greater at Newport than at Cardiff, and the release of wagons provided the collieries with sufficient empties to keep them employed the whole of this week. Pit wood keeps firm at 75*s.*, which is also now being quoted for inland supplies.

Colliery Examiners' Strike.—The lower grade colliery officials who are members of the South Wales Colliery Examiners' Association struck work the latter end of last week, and more than half the collieries in the Welsh coalfield were rendered idle as a consequence. It is estimated that the loss in output amounted to nearly 300,000 tons, but except for the supply of coals of inland consumption no great inconvenience was experienced owing to the large amount of stocks on hand. On Saturday, Mr. W. Brace, M.P., the Under Secretary for the Home Office was at Cardiff the whole of the day. He did not succeed in effecting a settlement notwithstanding the concessions offered by the owners. The examiners insisted upon an unconditional recognition of their organisation. Late on Saturday evening they decided to resume work without having achieved the object aimed at, stating they adopted this course "rather than imperil our nation in these days of stress and difficulty." The reason given for resuming work is certainly laudable, but it may be pointed out that these conditions of "stress and difficulty" prevailed before they came out on strike, and in normal times they have never once in the history of the coalfield ever suggested a resort to strike methods.

The Welsh Miners' Ballot.—The result of the miners' ballot on the down tools issue, has been particularly gratifying. The extremists and pacificists had made a determined attempt to induce the South Wales miners to vote in favour of a down tool policy in the event of the Government proceeding with their scheme for their combing out of colliery workers for the Army. The pacifists, however, have suffered ignominous defeats, and although the complete results are not yet to hand, the issue has now been placed beyond all doubt, for about 80 per cent. of the miners have voted against the advocates of the down tools policy.

TOWN PLANNING.—Sir William Collins, K.C.V.O., M.D., M.P., chairman of the Chadwick Trustees, will preside at a lecture on "Some General Aspects of Town-Planning after the War," to be delivered at University College, London, by Professor S. D. Adshead M.A., F.R.I.B.A., on Thursday, the 15th inst., at 5.30 p.m.

LARGE LIGNITE TRANSACTIONS.—The Ignatz Petschek concern, which has aroused considerable jealousy and dissatisfaction in Germany by the control it has obtained over important lignite deposits, has recently very materially increased its holdings, either by direct purchases, through works under its control, or through middlemen. Thus the Eintracht lignite and briquette concern, in Neu Welzow, has acquired Count Oppersdorf's lignite fields at Praschmar, and the Nieder Lausitz lignite works have bought the Fischer-Drochow lignite fields, at a price exceeding 10,000,000 marks. The Petschek concern has thus beaten the rich Ilse Briquette Company, and has also succeeded in buying the Erla mine and briquette works, the last outsider in the Nieder Lausitz lignite district. Negotiations are pending in regard to important lignite fields in East Germany. The Feis Lignite Company has increased its capital from 100,000 marks to 5,000,000 marks for the purpose of opening out new lignite fields.

THE SWEDISH MERCHANT NAVY.—The Swedish merchant navy, like that of almost every other country, has suffered severely during the war, the loss from the beginning of the second half of the year 1914 to the end of September 30, 1917, amounting to 286 vessels, having an aggregate tonnage of 176,895 tons. Although speculation has forced the price for steamer shares up to what thinking people consider mere fancy prices, and although in Norway especially, the formation of new shipping concerns is again proceeding at a great pace, a Swedish paper, prominent in matters concerned with shipping, unhesitatingly states that the prospects for shipping are now darker than ever. It is true that rates in the open market are fabulous, but so are expenses. A vessel with wood to England has to pay in insurance a sum which exceeds the freight by about 14,000 kronor, the actual result of the outward trip being a loss of about 57,000 kronor. Consequently the possible profit depends entirely on the home freight, and this is very problematical.

WOMEN ENGINEER STUDENTS AT WORK.

(*For Description, see Page* 485.)

FIG. 1. GRINDING SECTION FOR BOLTS AND PUMP SPINDLES.

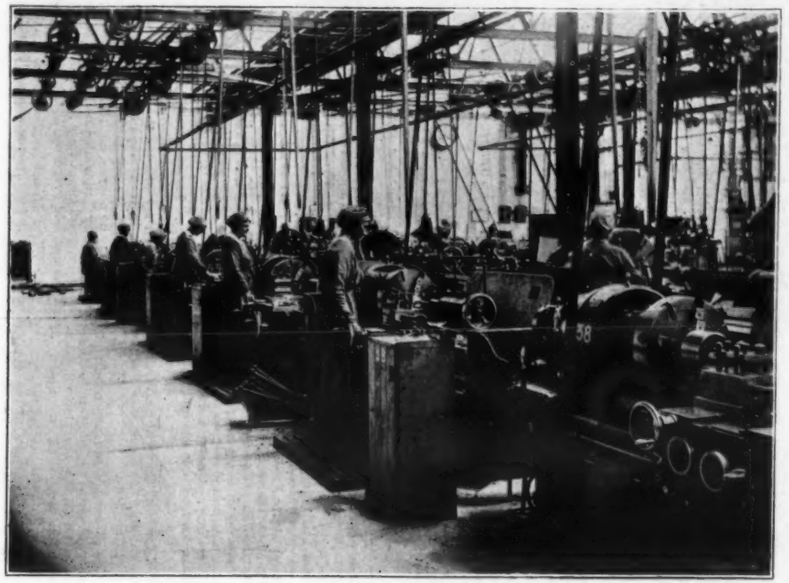


FIG. 2. ENGINE LATHE SECTION.

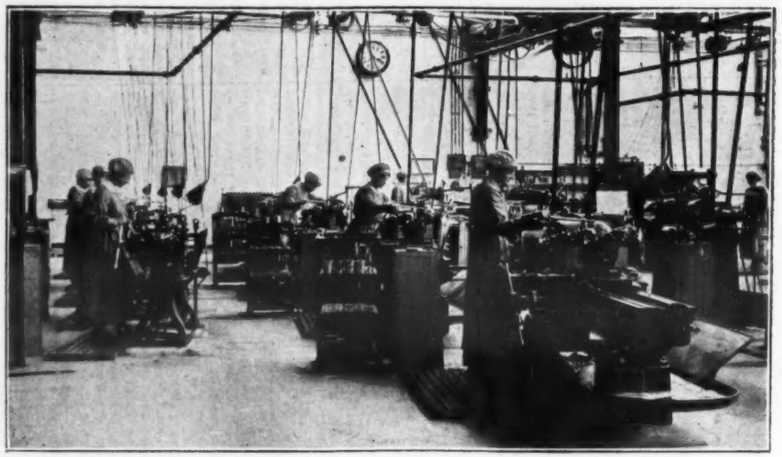


FIG. 3. SEMI-AUTOMATIC LATHE SECTION.

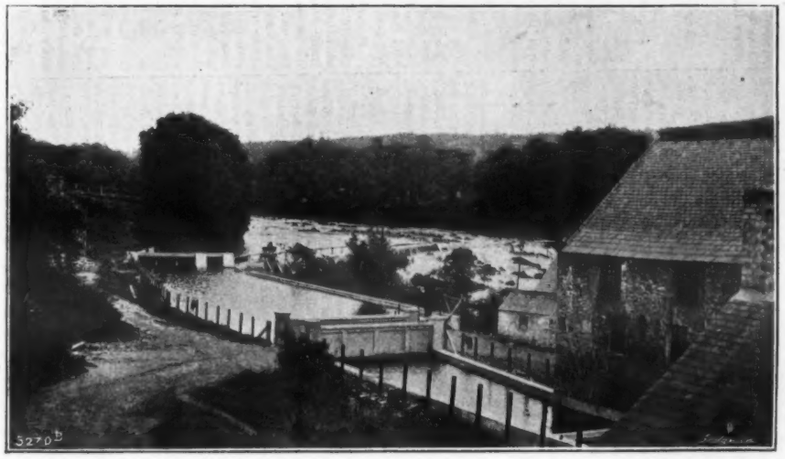


FIG. 4. RESERVOIR, LOOKING DOWN THE RIVER.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thick " "	£2	5	0
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Thin paper copies	£2	5	0
Thick " "	£2	9	6

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8508 GERRARD.

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NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 9, at 8 p.m., at the Institution offices, 39, Victoria Street, Westminster, S.W.1. The lecture will be given by Mr. H. J. Rickwood, entitled "Precision Gauges."

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 9, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. (1) "On the Thermo-Electric Properties of Fused Metals," by Mr. Charles Robert Darling and Mr. Arthur W. Grace. (2) "Triple-Cemented Telescope Objectives," by Mr. T. Smith, B.A., and Miss A. B. Dale.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, November 10, at 7 p.m., at the Institute, Wolverhampton Street, Dudley, when the President, Mr. J. E. Fletcher, M.I.M.E., will deliver his Presidential Address.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, November 10, at the Grand Hotel, Aytoun Street, when a paper on "British and Foreign Systems for the Protection of Inventions and Suggestions for Reform" will be read by Mr. V. A. B. Hughes. The chair will be taken at 6.30 p.m.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, November 13, at 7.30 p.m., at the Rooms, 207, Bath Street, Glasgow, when the Chairman, Mr. Archibald Page, will deliver his Inaugural Address.

THE INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.—Tuesday, November 13, at 7 p.m., in the Engineers' Club, Albert Square, Manchester, when the Chairman, Mr. C. J. Beaver, will deliver his address.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, November 14, at 8 p.m., in the Physics Lecture Room, University College, Gower Street, W., when Dr. E. G. Coker will read a paper entitled "Photo Elasticity for Engineers."

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, November 14, at 7 p.m., at the University, Edmund Street, when the Chair[illegible], Mr. S. T. Allen, will deliver his Address.

THE INSTITUTION OF MINING AND METAL[illegible]Y.—Thursday, November 15, at 5.30 p.m., at the Room[illegible]e Geological Society, Burlington House, Piccadilly, Lon[illegible].1. The following papers will be submitted for discussi[illegible] Slime Treatment on Cornish Frames: with particular r[illegible]ce to the Effect of Surface," by Mr. S. J. Truscott, Mem[illegible]er. "Comparative Concentration Tests on Wood and Fluted Glass Surfaces at Porco, Bolivia," by Mr. Harold A. Lewis, Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 16, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Paper:—"Some Notes on Air Lift Pumping," by Mr. A W. Purchas, of Wolverhampton, Associate Member.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 9, 1917.

MARINE ENGINEERING.

FOR obvious reasons relatively little has been published as to the advances made in marine engineering during the past three years. In fact our shipyards have during this time been so predominantly engaged on the construction of war vessels, that certain recent developments in the application of the steam turbine to cargo-boat propulsion come almost as a matter of surprise. That the turbine should have entirely displaced the reciprocating engine for large war-ships was perhaps not more than might have been anticipated, as even ten years ago the reciprocating engine was (with the possible exception of America) recognised as being, if not obsolete, at least obsolescent, for all high-speed war craft. At high speeds not merely was the turbine more economical than the reciprocator, but it made possible of attainment speeds impracticable with its rival. The high powers required for exceptional speeds were, moreover, developed with an ease and absence of anxiety to which the late Mr. E. C. Carnt at one time bore eloquent testimony. He contrasted the feeling of confidence and security with which he attended the full power trials of a turbined destroyer with the serious anxiety suffered on similar occasions with reciprocating machinery. A trial "all out" with reciprocating machinery necessarily implies somewhat high stresses on certain important elements of the machinery, such as the connecting rods, for example, and in spite of every care taken whilst the material was going through the shops, Mr. Carnt said he could never, till after the actual trial, be quite certain that no defective metal had got through. The remarkable overload capacity of the turbine has also great advantages. Turbines on a destroyer designed to develop some 35,000 s.h.p. have actually been worked up to 56,000, and in spite of the marvellous showing made by the Kent at the Falklands, when the engines were successfully forced so as to give a speed materially in excess of that obtained on the trial trip, the reciprocator is certainly inferior to its rival in this important point of overload capacity. That the turbine would not merely maintain, but would improve its position in the Navy was fully recognised when Mr. Hall-Brown reviewed marine engine practice in 1911. It was also clear that for high speed liners and for high speed cross-Channel services, the future also lay with the turbine. The reciprocator still held its own, however, in by far the most important portion of our mercantile service. As Kipling has said, "The liner, she's a lady!" but it is the cargo boats which form our principal maritime asset.

Of course many minds were at work on the problem of adapting the turbine to the tramp. It was obvious that some form of reduction gear must be employed, and three plans were under discussion and experiment when Mr. Hall-Brown gave his review, viz., electric reduction gear, hydraulic reduction gear, and ordinary toothed gearing. The two former had the advantage of dispensing with reverse turbines, but had a somewhat lower efficiency and generally permitted of but a limited gear ratio. They were thus hardly suitable for use on the tramp, and were in fact rivals rather of the combination of high-pressure reciprocating engines and an exhaust steam turbine (as fitted on certain medium-speed liners) than of the ordinary cargo boat marine engine. In the very valuable and informing presidential address recently delivered by Mr. Alexander Cleghorn to the Institution of Engineers and Shipbuilders in Scotland, it is stated that even in this field the prospects of the electric and hydraulic systems are not bright. "The mechanical system," he says, "makes the pace, and that pace seems likely to be rather too severe" for its competitors. In fact, Mr. Cleghorn claims and advances cogent data in support of his theory that the cargo vessel of the future will be fitted with geared steam turbines to the practical exclusion of every other form of propelling machinery. The introduction of double reduction gearing has greatly simplified the problem, making possible some highly important changes in the details of turbine construction, as well as greatly reducing machinery weights as indicated by Table I on the next page, due to Mr. Cleghorn, which shows comparative figures for different types of machinery in different services.

In Table I (*a*) refers to standard designs of nine or ten years ago; (*b*) and (*c*) are, Mr. Cleghorn says, representative of present practice with saturated steam and 100 deg. F. superheat respectively, whilst the arrangement proposed under (*d*) has so far been employed in cargo boat service only. The table is based on the use of coal as the fuel. The economies in machinery weights, in coal consumption, and in fuel costs are, it will be seen, very high, but the table gives no particulars as comparative capital costs. For some years to come these are, however, likely to be of relatively small importance, since it is generally considered that more freight will be on offer than tonnage capacity available. When a boat is liable to be laid up for long periods it may be wisdom to face higher fuel costs if these are coupled with a large reduction in capital charges, but for the immediate future it seems probable that the idle ship will be a rarity, and it might pay to face even a considerable enhancement of capital charges if thereby the running costs could be lowered.

It is, of course, well known that the mean diameter of a low-pressure turbine is independent of its rate of revolution. If the exhaust losses are to be reasonably low the mean diameter of the last row of blading must not be less than about $0.65\sqrt{\text{H.P.}}$ There is no such limitation applicable to the high-pressure end of the turbine. The use of double reduction gears, Mr. Cleghorn notes,

makes it practicable to run the low-pressure section at a different rate of revolution from the remainder of the turbine. As described by Mr. Cleghorn, the present practice is to divide the turbine up into three sections, each of which may be run at a different speed. The low-pressure section is designed for one-half of the total output, and the intermediate and high-pressure sections, which have their shafts independent both of the low-pressure section and of each other, develop each about a quarter of the total power. The speeds of revolution may be different for each section of the turbine, and are chosen so as to give ample blade heights and short and stiff rotors. The latter arrangement obviates any difficulty in the use of high superheats and reduces the importance of the loss by leakage over blade tips. This is still further reduced by the use of Sir Charles Parsons' system of "end tightening." Where this is applied, the blades are shrouded, and a thin cylindrical fin from the shrouding for each row projects so as to all but touch the next row of blades. All leakage over the blades has therefore to pass through this restricted area, and provision is made for adjusting the clearance here by shifting, in an axial direction, the rotor relatively to its casing. "Dummies" are dispensed with, the whole of the unbalanced thrust being taken on bearings of the Michell type. There is thus no loss from dummy leakage, which was often considerable in the case of direct connected marine turbines, and as the omission of the dummy shortens the rotor the latter is correspondingly stiffer and can work satisfactorily with smaller clearances than would otherwise be necessary. The advantages of this ingenious arrangement of the machinery are, it will be seen, manifold, and Mr. Cleghorn is probably running little risk of proving mistaken in holding that the introduction of high superheats and double reduction gearing marks "an epoch of advance without equal in marine engineering history."

Whilst, as the table shows, the plan is economical for all classes of vessel, its advantages are relatively greatest in the case of cargo boats, which constitute the bulk of our mercantile marine. A suitable propeller speed for such craft is 70 turns per minute, and with such a propeller speed and with single reduction gearing it is hardly practicable to run the turbines faster than 1,300 to 1,400 r.p.m., which is a low speed for turbines of any moderate output. By using double reduction gearing and subdividing the turbine in the manner already set forth, each element of the turbine can be arranged to drive a separate pinion, the high-pressure turbine being geared to 4,000 r.p.m., the intermediate to 3,000 r.p.m., and the low-pressure to 2,000 r.p.m. Machinery of this type is, Mr. Cleghorn stated, on order for a large number of cargo steamers. The reason why it was not adopted for the standard ships is probably to be found in the greater ease with which forgings for reciprocating engines can be obtained. Turbine rotors are of somewhat awkward form, and relatively few firms have had experience in producing such forgings.

From the standpoint of fuel consumption the steam turbine, even with high superheats, yields place to the Diesel engine, but the latter has certain well-known drawbacks. The most important is no doubt the high cost and scarcity of oil, but there are others of a mechanical nature. If the engine is to be of moderate weight, its rate of revolution must be rather higher than is desirable for cargo boat propellers.

In comparing steam with oil, Mr. Cleghorn considers the case of a ship fitted with motors developing 2,000 h.p. and equipped for a 20-day voyage. The total machinery weights (including boilers) would be, he states, ten tons less with the Diesel engine, and the fuel carried would be 250 tons of oil in place of 490 tons of coal. Allowing for differences in the wages bill, in the cost of lubricating oil and stores, the boat with the oil engine would have had an advantage of 150*l.* per voyage, so that it could compete successfully with its rival when coal cost 1*l.* per ton and oil 2*l.* 10*s.* As matters stand, he considers that even in circumstances peculiarly favourable to itself the Diesel engine is not more than equal to the modern steam plant working with high superheats.

The use of the latter will entail greater care in the boiler room. The feed water must be very pure and safeguarded from contamination with oil or salt water. Fortunately, as the turbine requires so little looking after in the engine room it will be practicable to give more supervision to the work of the stokers. Of course the turbines must also be carefully designed so as to avoid troubles from distortion. Whilst a superheat of 100 deg. F. gives a saving of 9 per cent. in steam consumption, the saving of fuel is only 5 per cent. to 6 per cent., and where low superheats are used on large ships the net result may, Mr. Cleghorn says, really represent an annual loss as compared with a vessel operating with saturated steam.

TABLE I.—*Comparative Figures for Different Steam Machinery Types.*

Type of Ship and Machinery.	Relative Fuel Consumption.	Relative Machinery Weight.	Relative Superficial Areas.	
			Engine Room.	Boiler Room.
1. Fast Ocean Liner.				
(*a*) 4 S.* triple-series direct-coupled turbines; cylindrical boilers—saturated steam	100.0	100.0	100.0	100.0
(*b*) 2 S. single-geared turbines; cylindrical boilers—saturated steam ..	89.0	93.0	90.0	92.0
(*c*) 2 S. single-geared turbines; cylindrical boilers—100 deg. F. superheat..	84.5	93.5	90.0	86.0
(*d*) 2 S. double-geared turbines; cylindrical boilers—200 deg. F. superheat..	75.0	88.5	86.0	77.0
2. Intermediate Liner.				
(*a*) 3 S. combination machinery; cylindrical boilers—saturated steam ..	100.0	100.0	100.0	100.0
(*b*) 2 S. single-geared turbines; cylindrical boilers—saturated steam ..	93.0	80.0	87.0	92.0
(*c*) 2 S. single-geared turbines; cylindrical boilers—100 deg. F. superheat..	88.0	81.0	87.0	91.0
(*d*) 2 S. double-geared turbines; cylindrical boilers—200 deg. F. superheat..	74.0	72.0	83.0	80.5
3. Cross-Channel Steamer.				
(*a*) 3 S. compound direct-coupled turbines; cylindrical boilers—saturated steam	100.0	100.0	100.0	100.0
(*b*) 2 S. single-geared turbines; W.T. boilers—saturated steam	91.5	75.0	100.0	97.0
(*c*) 2 S. single-geared turbines; W.T. boilers—100 deg. F. superheat ..	86.5	76.0	100.0	97.0
(*d*) 2 S. double-geared turbines; W.T. boilers—200 deg. F. superheat ..	73.5	68.0	95.0	86.0
4. Cargo Steamer.				
(*a*) S.S. triple-expansion reciprocating engine; cylindrical boilers—saturated steam	100.0	100.0	100.0	100.0
(*b*) S.S. single-geared turbines; cylindrical boilers—saturated steam ..	83.5	79.0	85.0	95.5
(*c*) S.S. single-geared turbines; cylindrical boilers—100 deg. F. superheat..	79.0	79.5	85.0	94.0
(*d*) S.S. double-geared turbines; cylindrical boilers—200 deg. F. superheat..	66.0	72.5	80.0	87.5

* S = screw.

TABLE II.—*Comparison of Mechanical, Hydraulic and Electrical Transmission Systems for a 20,000-h.p. Ship.*

Machinery Type.	Turbines with Double Mechanical Gearing.	Turbines with Hydraulic Transformer.	Turbines with Geared Electrical Generators and Motor-driven Screws.
Superheat	200 deg. F.	200 deg. F.	200 deg. F.
Propeller revolutions	90	140	90
Turbine revolutions..	2,400 & 1,500	About 1,000	2,400 & 1,500
Transmission efficiencies	0.965	0.92	0.885
Relative fuel consumption	100	123	109
Relative machinery weights	100	109	108

In one case considered in the address the adoption of 100 deg. superheat showed that after due allowance was made for the additional capital costs, the net resultant gain was only quarter of the saving in fuel consumption, and this gain would, it appeared, become a loss if provision were made for working with the superheaters out of action. As we have already mentioned, Mr. Cleghorn considers electric and hydraulic reduction gearing as out classed by the new type of mechanical gears. He gives the annexed Table II showing comparative estimates for a boat requiring 20,000 shaft horsepower. He observes that it is not yet certain that the floating frame advocated by Mr. McAlpine is in any way superior to arrangements in which the pinion is rigidly supported.

THE GAS ENGINEER.

GAS engineering was in the past regarded as a very limited branch of general engineering, but the developments during recent years have quite changed this point of view, and now, for the first time, we believe, an engineer who has made his reputation solely in this section of our profession has been elected president of the Institution of Civil Engineers. Mr. Harry Edward Jones took the chair last Tuesday evening at very short notice in consequence of the president-elect, Mr. William Barton Worthington, being unable to take office by reason of ill-health and the demands on his time occasioned by the war, and of Sir John A. F. Aspinall, the next vice-president in order of seniority, being too fully occupied on the Railway Commission. In a certain sense it is matter for congratulation that Mr. Jones has attained to this dignity during the war, for no industry in the country has been of more service in lifting us out of the deplorable condition in which we were in the early winter of 1914 than that which he so worthily represents. Everyone will remember the outcry there was about the scarcity of high-explosive shells, and the articles that were written blaming the military authorities for want of imagination and foresight in devoting the greater part of their efforts to the supply of shrapnel. They had a perfect answer, could it have been published. We were short—terribly short—of the materials for making high explosives, and it was only by the gas interests coming patriotically and indefatigably to the help of the Government that the shortage was overcome. The methods of gas-making were altered to produce a greater supply of the required residuals, new plant was put down to treat the tar, and every accustomed object, even the making of profits, was set aside in order that the army should be put on an equality, and eventually on more than equality, with the enemy. When the time comes for writing the history of the war the action of the gas companies and corporations, hitherto the objects of much grumbling and abuse, will be seen to have been a most important factor in our success.

The work of the gas engineer is by no means confined to dealing with retorts and mains, and such-like simple matters. Often he has to undertake duties calling for civil engineering skill of a high order. Gas works are growing in size, and the demand for economy is urgent, so that size and complication increase from year to year. Sites have to be chosen for their propinquity to railway and water facilities, and not for their convenience in other respects. Tanks for gasholders are both wide and deep, and must be carried far down, after going through good foundations, into shifting and water-bearing strata.

The holders themselves are so high that they may require several telescopic lifts, with all the risks caused by wind pressure and snow. Wharves and jetties must be built, whatever the defects of the ground, and heavy buildings erected absolutely safe from settlement and distortion. The easy-going days when the gas engineer had not to fear competition, and had therefore little need to study economy, have gone for ever. He has now to make experiments and face risks. Difficulties with labour oblige him to try new arrangements of retorts, to increase the yield of gas per ton of coal, to adopt gas as a means of heating retorts, to instal elevators and conveyors wherever possible, and to employ hydraulic or electric charging and discharging machines. The successful gas engineer need not fear comparison with any other branch of the profession in the width and variety of his attainments.

In the future the gas engineer will need to have a wide chemical knowledge as well. The plant recently put down in gas works will have to be utilised, and the wonderful range of materials contained in residuals worked up more or less on

the spot. How many there are no one can say, but already 57 are utilised, including 10 of the cyanogen series, 8 perfumes, 9 drugs, 19 colours, and a number available for conversion into explosives. Another revolution in the gas industry looms ahead. Already the direct use of gas to produce illumination in the Argand or flat-flame burner is almost extinct, and the generation of power and heat is the main source of demand. Mr. Jones stated on Tuesday night that in one working-class district the peak load of the year came on between noon and 1 o'clock on Sundays in July, when in every cottage the gas stoves and rings were occupied by the meal of the week. Our columns have recently shown the immense volumes of gas that are employed in metal-melting, not only for gold and silver at the Mint, but for much cheaper materials in engineers' foundries all over the country. The penny-in-the-slot consumer and the foundry have become the mainstay of the gas works everywhere, and will remain so until gas becomes the real residual and the tar and ammonia the objects to which the engineer directs all his efforts.

It has been our custom to reprint the address of the president of the Institute of Civil Engineers. Owing to the short period available, however, Mr. Jones was not able to present a prepared address. In place of it he spoke for some 40 minutes on the state of the gas industry, on the functions of the gas engineer and of his future prospects, and he held his audience interested in his words far more completely than is generally the case on such occasions. He spoke of what he had seen and experienced, and gave opinions and advice founded on his knowledge. The occasion was thoroughly successful and not the less so because the traditional 60 minutes were not fully occupied. Now that meetings take place before dinner instead of after, presidents will earn the goodwill of their audiences by not insisting too rigidly on their privilege of occupying an entire hour.

THE LATE MR. W. DUDDELL, F.R.S., C.B.E.

The death of William Du Bois Duddell is an irreparable loss to electrical engineering and physical science. He was a clear thinker of great originality, wonderful skill, and quite exceptional capability, and though his name has not of late been particularly identified with any great scheme, none of his colleagues would dispute his position in the very front rank of consulting electrical engineers. Scientists saw in him one of the most eminent experimental workers of his generation, ingenious in the design and application of measuring instruments. If his remarkable gifts as investigator, organiser and business man had not been so thoroughly appreciated, he might still be with us. When the war broke out, and the State officially recognised the value of scientific advice, his services were called in from various sides. He was a member of several advisory committees, and the war does not claim its victims at the front only. He would not spare himself until he broke down, and when he finally made up his mind to take the rest of which he had so long deprived himself, it was too late. The news of his death on Sunday, November 4, may come as a shock to those who had merely supposed him to be absent on national work.

William Du Bois Duddell was born in London in 1872, and received his first education in private schools. The year he spent in a college in Cannes, in Southern France, gave him a facility in the French language which proved very useful to him in later years at international congresses and visits abroad. In 1890 he entered the works of Messrs. Davey, Paxman and Co., at Colchester, to serve his apprenticeship until 1893, when he went to the Central Technical College at South Kensington, mainly to study electricity under Professor Ayrton and T. Mather. A Whitworth Exhibition and a Whitworth Scholarship were awarded to him in 1896 and 1897. In November, 1898, he made an almost sensational *début* in the Institution of Electrical Engineers by giving an account of "Experiments on Alternating Arcs by the Aid of Oscillographs," the outcome of researches he had been conducting in conjunction with a fellow research student, now Professor E. W. Marchant. The brilliant demonstrations of the simultaneous potential differences at the dynamo terminals and at the arc terminals, and of the current, electrified the audience. The oscillograph he had first described at the Toronto meeting of the British Association in 1897. There were various kinds of instruments in existence then for such measurements, but hardly any allowing the experimenter to watch what was really going on. His oscillograph was a development of Blondel's and a kind of D'Arsonval galvanometer, adapted to bifilar suspension: two phosphor-bronze strips stretched by means of a spring balance were so suspended within the gap of an electromagnet that the current flowed up one strip and down the other, tending to move the one forward and the other backward; the light reflected from the galvanometer mirror was received on a revolving mirror. This instrument was applied also to the study of "Rapid Variations of the Current through the Direct-Current Arc" (read before the same Institution in 1900), and in 1904 Mr. Duddell described his researches on "The Resistance and Electromotive Force of the Arc" before the Royal Society, dealing with various kinds of carbons, and subsequently also with metallic electrodes. That sodium vapours increased the conductivity of the arc enormously, and that the arc could be produced between heated glass rods, he observed in 1906. His examination of the "Periodic Variation in the Exciting Current of an Induction Alternator," produced by the superposition on the continuous exciting current of the field of alternations due to the machine itself, should also be mentioned here. Oscillograph studies of vowel sounds he demonstrated at the Institution of Electrical Engineers in 1905. These researches brought him many honours. The Institution of Electrical Engineers granted him two Paris premiums for his first two papers; the oscillograph was awarded a gold medal at the Paris Exhibition of 1904. The Royal Society elected him a Fellow, and afterwards awarded him the Hughes medal in 1912.

In that year Mr. Duddell, not yet quite forty years of age, was also president of the Institution of Electrical Engineers, succeeding Mr. de Ferranti. He was the first new president in the new home of the Institution on the Victoria Embankment, and had as vice-president and president-elect taken far more than his share in the heavy work which the new home, and, further, the revision of the Articles of Association of the Institution, had involved. Yet he looked a young man, and some members thought that his turn might have been left to a later date. But the selection of the council had been made for very good reasons, in full recognition also of his business capacity, and he was re-elected president for 1913–14. He had joined the Institution as a student, and had passed through all stages of membership. When Mr. Duddell, in 1912, delivered his presidential address—which, dealing with progress in many branches of electrical engineering, required study for the proper appreciation of its detailed information—Sir John Gavey, seconding the vote of thanks, mentioned that he had once, in conversation with Mr. Duddell, regretted the want of an instrument to measure the energy received in radiotelegraphy at various distances. Mr. Duddell had replied that he thought it could be done, and a few weeks later he had brought an instrument ready for testing. The results of those tests which Mr. Duddell conducted, together with Mr. J. E. Taylor, were communicated to the Institution of Electrical Engineers in 1905, and Mr. Duddell also lectured on the same subject in the École Supérieure des Postes et Télégraphes at Paris. Mr. Duddell excelled in exact measurements, and a great deal of his later work had reference to radiotelegraphy. His musical arcs dated from 1901; a water model of these arcs he exhibited in 1914 before the Physical Society. In that society he also described, in 1904, his thermogalvanometer, a kind of twisted strip, after Ayrton and Perry, for measuring small currents of high frequency. The following year he showed in the same society a high-frequency alternator for 120,000 periods, which he further improved in 1912. These alternators are for radiotelegraphy, for which his variable condenser of 1914 was likewise designed; the capacity of this condenser is proportional to the square of the rotation of the moving sector. As president of the Commission Internationale de Télégraphie sans Fils, he gave, at Paris, in 1914, a summary of the development of radiotelegraphy, and in 1916 he communicated an article on the same subject to the *Annales des Postes et Télégraphes*. He also measured Röntgen-ray currents; he was president of the Röntgen Society in 1907. The "Short Spark Phenomena" which he demonstrated in the Physical Society in 1908 concerned high-frequency oscillations set up in the secondary of an induction apparatus by producing a short arc of microscopic dimensions.

As an experimental lecturer Mr. Duddell was unsurpassed. It was he, and not, as usually, the assistant, who took charge of the demonstrations. He astounded those who listened to his evening discourse at the British Association in Leicester, in 1906 on "Arcs and Sparks for Producing Oscillations," or to his Royal Institution lectures, "How to Improve Telegraphy," in 1906, and on "High-Frequency Currents," in 1912, and to his juvenile Christmas lectures delivered in the same Institution on "Signalling from Primitive Man to Radiotelegraphy in 1906," and on "Modern Electricity," in 1909; for once the juveniles and the professors of his audience were equally interested. The most difficult and complicated experiments looked simple and easy when performed by him, and the fertility of his mind to devise models explaining intricate phenomena never failed him. The juvenile lectures mentioned proved the most popular during modern decades, and one almost regrets that Mr. Duddell did not become a teacher. His expositions and contributions to discussions were always remarkably lucid and to the point. But the routine of a professorship did not attract his ever-active brain, and he selected the profession of a consulting engineer. In that capacity he was connected with the Post Office. Two of his papers should finally be mentioned as to his connection with central station work. In 1912 he presented to the Institution of Electrical Engineers a joint paper with Messrs. A. H. Dykes and H. W. Handcock, on the "Control of Meters, Public Lamps and other Apparatus from the Central Station," a problem that had been practically shunned, and in 1913 another paper on "Pressure Rises Due to Resonance, Switching and Arcs."

Among the honorary appointments he held were those of secretary to the delegates of St. Louis International Electrical Congress of 1904, and of secretary to the International Conference on Electrical Units and Standards, which met in London, 1908; on the latter occasion he proved an invaluable secretary and interpreter. The last honour conferred upon him was the Commandership of the Order of the British Empire, created last August. He practically discharged his last honorary duty when he presented the treasurer's account to the Physical Society at its annual meeting of February 9. That he was ill was plainly visible, and he left that meeting determined to suspend all work until sleep had restored his strength. Rest temporarily restored him, but his health was broken, and he succumbed on Sunday last. The funeral took place yesterday at Brighton, where his father, the late Mr. George Duddell, used to reside.

PYROMETERS AND PYROMETRY.

The first meeting of this session of the Faraday Society, held at the Royal Society of Arts on Wednesday, November 7, was devoted to one of the general discussions which have given the Faraday Society a standing of its own. The discussion on "Pyrometers and Pyrometry" was opened at 5.30; it was resumed after a dinner interval at 8.30, and had to be brought to a close at 10.45. Twelve papers and communications were on the list; no time was wasted, and many members would have preferred to continue the discussion. As usual on such occasions, an instructive exhibition of instruments was combined with the meeting. In taking the chair Sir Richard T. Glazebrook, a past-president of the society, paid a warm tribute to the many-sided work of the absent President,

Sir Robert Hadfield. Referring in his introductory remarks to the early days of the National Physical Laboratory, he stated that it had been mainly due to Sir Andrew Noble that Dr. Harker had then been able to take up high-temperature work at Teddington. In those days they had chiefly looked to the Bureau International des Poids et Mesures for guidance. But high-temperature thermometry was not particularly studied at Sèvres, and the later negotiations for international high-temperature standards had been mainly with Washington and Berlin. By September, 1914, the first International Conference was to have assembled at Berlin. As to the importance of the subject Sir Richard contented himself with one exemplification. They had quite recently been asked to advise on the treatment of a special steel, and had been pained afterwards to hear that more than 40 per cent. of the articles made had been rejected. The reheating had been effected, it was found, in a smith's fire at what the men had considered the right temperature. Sir Richard had a high respect for workmen's experience; but such cases only proved that the men had to be taught better methods and to be supplied with suitable intruments.

Production of High Temperature and its Measurement.

The first paper on the list was one by Dr. E. F. Northrup, of Trenton and the Palmer Physical Laboratory, Princeton, N.J., on the "Production of High Temperature and its Measurement." The use of carbon as a resister, he explained, was limited by the fact that carbon entered into combination with many elements at high temperature; even when direct contact between the carbon and material was prevented, reducing gases were generated which were, moreover, carriers of what he assumed to be particles of free carbon, so that tungsten, molybdenum and tantalum, *e.g.*, quickly became brittle in a carbonaceous atmosphere. Tungsten could serve as a resister, in the shape both of wire or ribbon or of a tube; the latter required a reducing atmosphere of hydrogen, but offered great possibilities. The resister furnace, especially as a melting furnace, unfortunately had a low thermal efficiency. Supposing copper were to be melted in a graphite crucible. The crucible would be placed within an alundum tube, which was outside-wound with nichrome wire, itself jacketed by a cylinder of a heat insulator of considerable wall-thickness. With this arrangement the heat generated in the wire had to travel through, say, 0.5 cm. of insulating material before reaching the copper, and through twenty times as much insulation before reaching the outer furnace wall. If the wire quickly attained 1,282 deg. C. (the maximum safe temperature), the heat gradient from wire to copper would first be of that order, and heat would flow twenty times more quickly to the copper than to the outer wall. The copper would soon melt, at 1,082 deg. C., and then that gradient would be reduced to 200 deg. and less, whilst the gradient to the outer wall remained as high as before. Thus the heat available for fusion became diminished to a small fraction of the heat generated in the nichrome. If the metal melted at the maximum temperature, the efficiency of melting would be zero. In the ideal furnace the heat should appear directly in the furnace walls, or, better still, in the substance to be heated, and should not be introduced from outside. That was possible in an induction furnace. The ordinary induction furnace interlinked an electric current and an iron magnetic circuit, however, so that the simplest form of crucible construction was not realisable. Owing to the different expansions of refractory material and metal it was not permissible to let the metal solidify in the furnace, and the furnace had to be started with preheated metal, which had to be removed before freezing. The induction furnace, moreover, was a step-down transformer with large magnetic leakage; it did not lend itself to special atmosphere or vacuum-working, and it did not admit of very high temperatures.

His own induction furnace dispensed with all magnetic interlinkage, and depended directly on the electromagnetic induction produced in the walls of the crucible or in its contents by sending high-frequency oscillating currents through a coil surrounding the crucible. When a condenser of capacity C was charged to V volts, potential energy was stored in the dielectric to the amount of $\frac{1}{2}$ C V^2, and the discharge of the condenser released this energy as kinetic energy in the form of radiation (for radiotelegraphy) or heat. He thus utilised a Tesla coil arrangement in which the volts were transformed down and the current intensity was raised. His apparatus consisted of adjustable reactance, transformers, an entirely new type of discharge gap (silent and without moving parts, not described) and two banks of condensers, on a two-phase supply circuit of 60 cycles at 220 volts. The currents passed through 50 turns of the coil, surrounding the crucible at a sufficient distance to ensure both electric and heat insulation. A furnace of this type melted 45 lb. of brass in 35 minutes at an expenditure of 18 kw. His vacuum furnace contained a crucible of Acheson graphite, 14 cm. diameter, 18 cm. high, filled with tin or glass,

Fig. 1. PYROVOLTER CIRCUITS

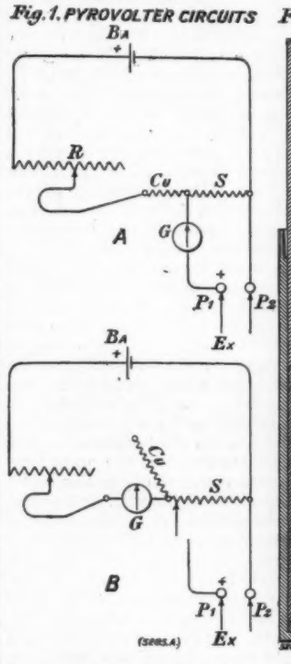
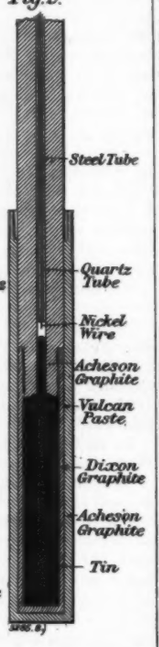


Fig. 2.



this material being heated to 1,600 deg. C. in 40 minutes or 50 minutes; a vacuum of 1 cm. of mercury could be maintained; certain kinds of glass evolved gas, however, and turned frothy. Cylinders or crucibles of graphite of the dimensions stated could be heated to 1,600 deg. and cylinders of metal, &c., be heated to melting; platinum had not been heated yet, but the thermal efficiency was 60 per cent., and the furnaces operated on two-phase circuits both at full load and small loads with high efficiency. At the condenser terminals the tension was 5,400 volts or 7,200 volts; the frequency was the natural period of the circuit, 25,400 cycles or 12,500 cycles per second. The crucible was earthed and surrounded by a cylinder of quartz glass for electric insulation; the whole furnace was provided with a grounded metal cage for safety. These "Ajax" furnaces were developed by Mr. Northrup with the aid of the Ajax Metal Company, of Philadelphia. When metal scrap was fused in magnesia crucibles, innumerable small arcs were formed between the metal particles; a layer of silox, 1 cm. in thickness, about the crucible, kept the inductor coil below red-heat when the crucible contents were above 1,400 deg. C.

Passing to temperature measurement, Dr. Northrup remarked that owing to the contamination of platinum-rhodium thermocouples by hot gases he had never been able to use these couples except intermittently at temperatures above the melting-point of nickel in a reducing atmosphere. Protected from access of gases, couples of tungsten-molybdenum were recommendable for extremely high temperatures, though they gave only a feeble electromotive force. For works practice he had devised a robust, portable instrument, the Northrup pyrovolter, which operated on the potentiometer principle, but was not so delicate as a potentiometer. The pyrovolter resembled a portable galvanometer; Fig. 1 explains its construction. The current from the dry cell BA (Fig. 1A) passes through the rheostat R and the fixed resistances Cu (equal to the resistance of the copper coil of the moving element of the meter G) and S; S is of manganin and fitted with potential tapping-off connections; the current flowing through S is varied by adjusting R, so that a varying E.M.F. is applied to the potential leads due to the drop of potential over the resistance, S. The moving element of G is coupled in series with the unknown E.M.F. Ex through the binding screws P_1, P_2, across S, so that the meter serves as galvanometer to establish a balance between Ex and the drop across S. This adjustment is effected by turning a button (not marked) clockwise to increase the current; when balance has been attained the pointer rests over the line at the extreme end of the scale. Another button (not shown) is then pressed, and G is substituted for Cu (Fig. 1B below); as all these resistances are of copper, that substitution may be effected at all temperatures. The current through S is thus measured, and this current being proportional to the potential drop across S, which had been balanced against Ex, the E.M.F. Ex to be measured is read off on a deflection instrument. One of the advantages of this instrument was that the readings were independent of the temperature coefficient of the pyrovolter.

Another interesting novelty of Dr. Northrup's is his tin pyrometer, which utilises the linear expansion of molten tin. Tin, melting at 232 deg. C., boiling at 2,270 deg. (Greenwood), did not, he had found, evaporate appreciably below 1,680 deg.—in a reducing atmosphere, we should add—was not contaminated by CO, and did not form a carbide with graphite. The electric resistance of liquid tin increased proportionately to the temperature, and the liquid metal thus afforded an extraordinarily large temperature range for resistance measurements (his tin resistometer) and for pyrometry. The tin of his tin pyrometer was contained in a bulb of close-grained graphite (Fig. 2) and expanded above 700 deg. C. into the graphite stem until it made contact with a nickel wire, which was provided with a quartz sheath and an outer steel tube. The nickel wire projected from the upper end of the pyrometer tube; it could be pulled up to variable heights, and the instrument was calibrated by determining the level of the tin column for two temperatures controlled by thermocouples, assuming the expansion of the tin in contact with graphite to remain regular up to 1,680 deg. at any rate. Like a mercury bulb, this pyrometer indicated not the temperature at a point, but the mean temperature over the space occupied by the bulb. To prevent slow oxidation of the graphite the bulb and stem were fitted with a tube of a carborundum composition; the clearance between the bulb and the jacket might be filled with molten tin or glass to keep out all gases. The instrument had not been in practical use yet; but molten tin, which could be obtained as pure as nitrogen, seemed to be a material of great possibilities for measurements of electric resistance and temperature above 1,550 deg. C.

Pyrometer Standardisation.

Messrs. Ezer Griffiths, D.Sc., and F. H. Schofield, B.A., B.Sc., of the National Physical Laboratory, reviewed the problems of "Pyrometer Standardisation," indicating the basis of the temperature scale and setting out some of the errors to which pyrometric observations are liable. Mr. Griffiths stated that the standard scale of temperature, it was now agreed, should be thermodynamic; but as gas thermometers were very cumbersome and fragile, the scale of a pyrometer was generally obtained by steps: (1) The gas-thermometer worker compared his instrument with a thermocouple; (2) the calibrated thermocouple was used for determining the freezing-points of some metals; (3) with the freezing-points referred to the gas thermometer, a thermocouple was standardised; (4) the couple and the pyrometer in question were then compared. The experimental difficulties of gas thermometry

were very high, and the war had interrupted the international negotiations. For the range 0 deg. to 100 deg. C. the hydrogen scale had been adopted; the platinum resistance thermometer served for the range freezing-point of mercury (− 38.88 deg. C.) to boiling-point of sulphur (+ 444.5 deg. C.); other fixed points were the boiling and melting-points of certain metals and compounds [compare our reports on the work of the National Physical Laboratory, July 23, 1915, page 91, and July 13, 1917, page 33], to which recent work had added the melting-points of nickel (1,452 deg. C.), palladium (1,549 deg.), and the second order melting-points of tin (231.8 deg. C.), cadmium (320.9 deg. C.), zinc (419.4 deg. C.), common salt (801 deg. C.) and, further, the interesting eutectic of nickel and graphite (1,330 deg. C.). Thermocouples of platinum alloys had to be protected very carefully from contamination with metallic vapours, reducing gases and carbonaceous matter; rhodium, and especially iridium, were, moreover, volatile. To detect contamination they used, at Teddington, a modification of the method of White, of the Geophysical Laboratory, Washington. In this apparatus the wire to be tested was laid across two parallel copper wires, each soldered to the top of a copper tube, the one tube being heated by steam, the other cooled by water; the thermo-electric force between the two points of the wire (under test) in contact with the two copper wires was measured, and the test wire was then shifted to make contact at other points; a homogeneous wire would give the same reading throughout. Oxidation of the thermocouple wires was also to be prevented, and when they were sheathed with porcelain a time lag was introduced which was very troublesome in measuring the temperatures of liquid metals. The contamination troubles had also brought the Siemens platinum resistance pyrometer into disrepute in the early days; except for the time lag in measuring moving temperature, those thermometers were now remarkably free from liability to giving false readings.

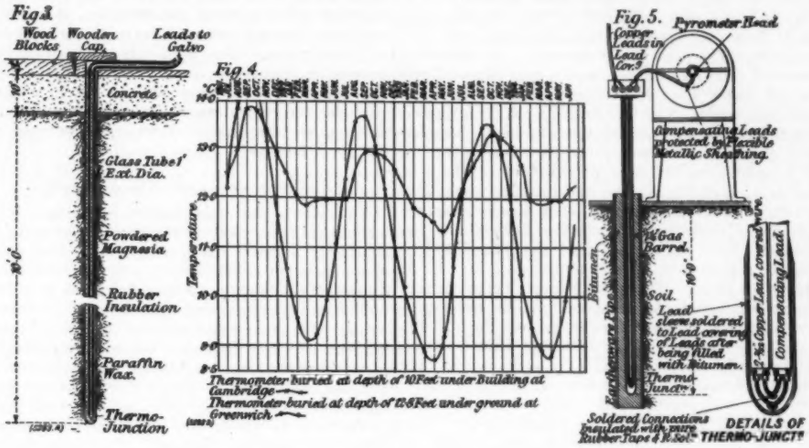


FIG. 6.

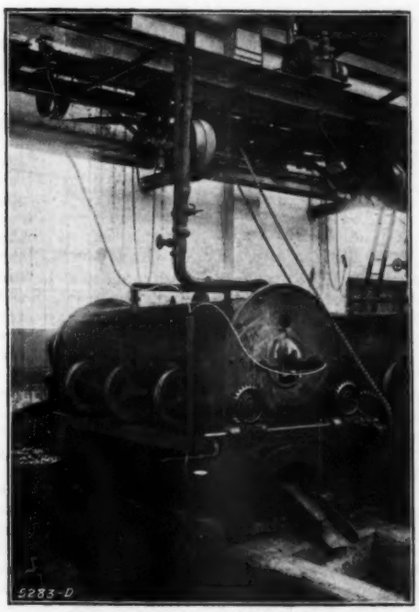


FIG. 7.

Total radiation pyrometers should theoretically require comparison with a gas thermometer at one temperature only for their standardisation. But the "black body" occupied the rôle of the "perfect gas" in gas thermometry, and in the formula $e = a\,T^b$ connecting thermo-electric force e and temperature T, b was not really a constant of the value 4. The radiation from muffles and furnaces was nearly black-body; the radiation from molten metallic surfaces was much affected by oxidation and haze and vapours, however. Optical pyrometers were of the disappearing-film type (a telescope, in which the image of a hot object was focused in a plane containing a lamp filament), the polarising type and the wedge-absorption type. Theoretically the polarising type, essentially a König spectrophotometer, was the best, and admitted of considerable extrapolation by the formula of Wien or Planck. By the interposition of neutral-tinted glass in the path of the beam a second scale, covering a higher range than the primary scale, could be obtained; but the value of the constant b of the formula (not the same as the just-mentioned b) was not really constant for all instruments using the same wave-length. At Teddington they found the average value $b = 4{,}860$; theoretically it should be 4,840 for the usual wave-length 0.65 μ. Optical pyrometers were less liable to "black-body" errors than those of the total-radiation type; to convert the apparent temperature of an oxidised-iron surface to true temperature meant only a correction of 4 deg. C. at 1,000 deg., and up to 700 deg. the correction was negligible.

We have given a very brief *résumé* of the paper, and would refer our readers to our issue of July 13 as to the way in which Messrs. Griffiths and Schofield now standardise optical pyrometers.

Burying the Cold Junction of a Thermocouple.

The paper on "The Advantage of Burying the Cold Junction of a Thermocouple as a means of Maintaining it at Constant Temperature," by Mr. R. S. Whipple, of the Cambridge Scientific Instrument Company, was a welcome contribution to the discussion. Thermocouples have gained considerable popularity, and would find more general use still if they were not rather troublesome in certain respects. A brief introduction of the subject may be acceptable. The thermocouple is an instrument for determining a temperature by measuring a thermo-electric force. Two metallic wires of equal lengths, but different materials, are soldered together at the one end; the junction is placed at the spot the temperature of which is to be determined; as a rule—*e.g.*, in furnace work—this is the "hot junction." The other ends of the wires are soldered to the copper leads connecting the wires with the indicating instrument, a galvanometer or potentiometer; these two joints form the "cold junction," which is to be kept at constant temperature. The instrument is to indicate the difference in temperature between the cold and the hot junctions, and will do that if there be no further seats of thermo-electric force in the whole system. Any thermo-electric forces in the leads and at the binding screws would necessarily vitiate the results; the wiring is hence a matter of importance in such installations. The thermocouples themselves may consist of noble metals or alloys, or of base metals and alloys. The base-metal couples give the higher electromotive forces; thus bismuth-antimony yields about 100 microvolts per degree Centigrade, constantan-iron gives 53 microvolts, copper-constantan 40 microvolts, nickel-iron 32 microvolts, platinum alloy-platinum 5 microvolts of the couple-wires. Where oxidation, corrosion and fusion have to be feared, noble couples (platinum with 10 per cent. of rhodium or iridium against platinum) have or had to be used; such couples will give, *e.g.*, 15 millivolts for a temperature difference of 1,500 deg. C. Of late base-metal couples have been much improved; but the trouble with the constancy of the cold junction remains or remained, and Mr. Whipple spoke on this point.

In the laboratory, he pointed out, the cold junction was generally immersed in melting ice. In the furnace-room the ice vessel would have to be at a considerable distance from the furnace, and the use both of ice and of considerable lengths of connecting leads was almost impossible. That difficulty had to a certain extent been overcome by the use of thermos flasks, which could now be seen installed near the furnaces of large works. The flasks were generally filled with oil, the mercury thermometer in which, with a diurnal temperature variation of 10 deg. or 15 deg. C., would keep constant within 2 deg. C. With the aid of the compensating leads of Mr. W. S. Peake (of the Cambridge Company; patented 1909) the cold junction of a platinum couple could be transferred a considerable distance from the pyrometer head, and these compensating leads of dissimilar alloys or metals had further rendered it possible to adopt a

proposal made by Professor Anthony Zeleny, of Minneapolis, in 1902, namely, to bury the cold junction in the ground. The compensating leads were to set up, at the terminals of the recording instrument, a subsidiary thermo-electric force to eliminate the effects of changes in the temperature of the cold ends of the couple, and thus to transfer the effect of the cold ends from the couple to the instrument. In such a case we should have two thermocouple wires from A (hot junction), A B and A B_1, A B soldered at B to the one compensating lead B C of copper-nickel, and A B_1 at B_1 to the other compensating lead B_1 C_1 of copper; the two compensating leads might go directly to the galvanometer or end in a junction-box, from which copper wires finally extended to the galvanometer.

Experiments, Mr. Whipple continued, on burying the cold junction had, in their works at Cambridge, begun in 1911. A hole was driven through the floor of a testing-room into the ground underneath to a depth of 10 ft. A glass tube of that length was put in the hole, and the couple (of copper-constantan, the latter being an alloy of 60 per cent. copper and 40 per cent. nickel) was lowered into the tube, paraffin wax being run into the bottom end for a depth of 18 in., and the rest filled with powdered magnesia (see Fig. 3, page 499). The four wires projecting from the tube, representing the thermocouple and the leads respectively, were taken to terminals in two lead-covered cables; thus any couple having the same thermal constants could be joined to the buried junction (as Fig. 5 shows more plainly). This couple, of Fig. 3, it will be understood, was buried not to serve as cold junction, but to measure the temperature 10 ft. down in the ground, and to see whether that temperature was sufficiently constant, the other cold junction being immersed in ice. The force of the couple was measured, by means of a potentiometer, every week during the two years, July, 1911, to July, 1913; later, up to June, 1914, measurements were taken once a month. The temperature curves thus obtained are illustrated in Fig. 4 in comparison with the curves which the Astronomer Royal, Sir Frank Dyson, found for the same period with a mercury-in-glass thermometer buried 12.8 ft. deep in the open ground at the Greenwich Observatory. It will be seen that the range of the temperature fluctuations was greater at Greenwich than at Cambridge. Thus in 1912 the monthly means at Cambridge fluctuated only between 11.89 deg. C. in March and 12.95 deg. C. in October; whilst the corresponding figures for Greenwich were 9.11 deg. and 13.07 deg. C. The ranges for the three years were, at Cambridge, 1.91 deg., 1.49 deg. and 1.38 deg. C. (mean, 1.59 deg. C.); at Greenwich, 5.5 deg., 4.96 deg. and 4.75 deg. C. (mean, 5.06 deg. C.), although the Greenwich thermometer was buried 2.8 ft. deeper than the Cambridge thermometer. The chief reason for the difference was probably that the ground in Greenwich was exposed, but at Cambridge was covered by a building. The thermocouple at Cambridge was 10 ft. from the exterior walls; in a larger building the constancy might be still more satisfactory, and a couple was now buried under a much larger building at a depth of 20 ft. It was rather a pity that Mr. Whipple's observations did not cover the long, severe winter of 1916–17.

Mr. Whipple referred, however, to the long-continued observations, conducted by Dr. Arthur Rambaut, from 1899 to 1910, on underground temperature at the Radcliffe Observatory, Oxford. The maximum temperature range of the thermometer buried there, 9 ft. 11½ in. below the surface, was 6.88 deg. C., varying from 14.42 deg. (September, 1899) to 7.54 deg. (March, 1909); the mean monthly ranges were almost identical with those observed at Greenwich. At a depth of 66 ft., Dr. Rambaut calculated, the temperature in the Oxford gravel should not fluctuate by more than 0.01 deg. C. throughout the year. If the gradient were the same at Cambridge, a constancy within 0.016 deg. C. should occur at a depth of 50 ft.; that would be well below the river level at Cambridge, and the fair constancy Mr. Whipple had observed at Cambridge was rather remarkable, because the couple could be only 3 ft. or 4 ft. above the high-water level of the Cam. Rainfall further complicated (and lowered) the constancy of the underground temperature by raising the diffusibility of the soil, as Professor H. L. Callendar had shown at Montreal; for this reason also a greater constancy could be expected under a floor of larger area.

The buried couple had already proved convenient in works practice, and the diagram, Fig. 5, exemplified one of the most successful installations; this installation was due to Messrs. Frank and Kievits, of Messrs. Kynoch, Limited. A steel tube, closed at one end, was buried in a small earthenware drain pipe to a depth of 10 ft., the space between tube and pipe being filled with bitumen. The copper leads were soldered to the compensating leads from the couple, thus forming the cold junction. The joint was protected by an insulating material such as bitumen, and a lead cap soldered to the outer lead sheathing protected the thermometer wires. The two cables were then pushed down the steel tube, which was filled with bitumen and magnesia. It was sometimes convenient to fit terminals on the head of the tube of the cold junction, as in Fig. 5. The cold junction might also be constructed in the form of a thermometer in which the protective sheath was driven into the ground. Such an arrangement was illustrated in Fig. 6, reproduced by the courtesy of Mr. G. S. Haven, of Messrs. White and Poppe; their thermocouple measured the temperatures in an explosives factory. The arrangement of Fig. 7 differed slightly; the cables from the buried couple ran directly to the couple placed in the annealing furnace and to the temperature indicators, without interposition of any terminals. Mr. Kievits had found that the temperature of the soil (Fig. 5) did not vary by more than 1.5 deg. C. over a period of six months. Concluding, Mr. Whipple stated that one might rely that the temperature at 10 ft. below the floor of a fairly large building would not vary by as much as 2 deg. C. throughout the year, and that the use of Peake's compensating leads did away with practical difficulties in burying the junctions in works in the case of platinum couples. With base-metal couples matters were even less complicated, as the accuracy required was smaller, and the protection of the more robust couples simpler.

(To be continued.)

NOTES

Films of Metals and Salts in Glow Lamps.

Professor W. Reinders, of Delft, and Mr. L. Hamburger, of the Eindhoven Laboratory of Messrs. Philips' Carbon-Filament Lamp Works, have submitted the sublimation deposits which form on the inside of incandescent lamp walls to examination by the ultramicroscope. The deposits consisted either of the carbon or the metal of the filament, or of the salts with which the tungsten filaments were covered. Peculiarities noticed in the case of salt deposits, common salt, sodium oxide, sodium tungstate, &c., make it advisable to mention their case first (Proceedings, Amsterdam Akad., Wetenschapen, 1917, pages 958 to 968). The film of salt settling on the wall was colourless and invisible as long as the bulb remained intact. Under the ultramicroscope the deposit appeared optically homogeneous, and like a vitreous undercooled layer, from 0.0003 mm. to 0.001 mm. in thickness. When the bulb was opened, so that the moist air gained access, the film turned opalescent, the ultramicroscope began to reveal a network texture, and after some hours cubic crystals could be distinguished. In order to preserve the still homogeneous film for future study, the authors admitted Canada balsam into the bulb; then the slow crystallisation of the salt took place only in the spots which were not covered by the balsam. When a silver filament was heated to red glow by the current, a film settled on the glass which was first yellowish-green, and passed through orange, red, violet and blue as the thickness increased, An absolutely homogeneous film was not observed, but the yellow deposit consisted of smaller particles than the red and blue; these colours agree with Rayleigh's studies of 1871. According to Knudsen the metallic vapour particles impinging upon glass walls are not reflected when the walls are cooled; in the case of mercury Knudsen did not observe any reflection when the glass was cooled to — 135 deg. C., for silver Reinders found the lower limit of reflection, that is to say, the temperature at which all the vapour condenses on glass, at 575 deg. C. Gold resembled silver in its behaviour, the colour of the deposit changing with its thickness. Tungsten gave only grey or black deposits. The first film of tungsten was, indeed, colourless; films of a muddy grey colour consisted of particles of about 0.5 $\mu\mu$; there seemed to be no reflection of tungsten particles by the glass wall, which accords with Langmuir's observations. Reinders and Hamburger also experimented on the kathode volatilisation of metals by suddenly sending powerful currents through loops of thin wires. The films then obtained were coarser in structure than the evaporation films; the tungsten films were always black, and the particles had diameters ranging from 2 μ up to 5 μ; with slow volatilisation finer particles were also obtained, however.

Zirconia and Zirconia Apparatus.

Zirconia is not only highly refractory, but it also resists the action of acids and alkalis, is a bad conductor of heat, and having, like quartz, a very low expansion coefficient, is able to bear abrupt temperature changes. Apparatus made of zirconia incline to cracking, unfortunately. To a certain extent this tendency can be met by suitable additions to the zirconia; but most mixtures are more fusible than zirconia. According to E. Podszus, the zirconia should first be melted and ground to an exceedingly fine powder with the aid of the mills to which we drew attention in a paragraph on "Keramic Objects" (Engineering, September 7, page 249). A paste is then made of the zirconia with water and some organic binding agent; when compression can be applied, no binding agent is needed. The moulded articles are burnt at 2,300 deg. C. or higher temperature; if the temperature cannot well be raised above 2,100 deg. C., some phosphoric acid or boric acid may be added to the paste; these additions would be expelled again at 2,100 deg. C. The great difficulty is to melt the zirconia. For this purpose Podszus (*Zeitschrift für Angewandte Chemie*, 1917, pages 17 to 19) embeds the carbons of a vertical arc in the zirconia. A little zirconia turns into carbide which covers the lower electrode; this carbide conducts the current, and a small cavity is formed round the electrodes. The carbons may then be pulled further apart; the arc burns quietly, and the zirconia melts on the walls of the cavity. With an arc of 50 amperes to 100 amperes at 220 volts, finally 30 cm. in length, Podzsus claims to fuse several kilograms of zirconia in half an hour; as he refers to French patents, however, the information is perhaps not so complete as it might be. The arc really burns first between the upper carbon and the liquid zirconia, although the latter is practically an insulator. Thoria is melted in a similar way. With the aid of a Lummer-Kurlbaum pyrometer the melting-point of zirconia was, in three determinations, found to be 2,950 deg., 2,950 deg. and 3,000 deg. C. The oxide was not reduced by hydrogen at 2,200 deg. C., and rods of zirconia wound with tungsten wire and heated to the highest temperature in a high vacuum did not show any loss by volatilisation. The pure zirconia is almost white, though generally yellowish with traces of iron, and also discoloured by long heating; it is almost as hard as corundum, and difficult to disintegrate; when hard steel balls are used in mills, some iron is taken up, which can be extracted again by hydrochloric acid, however. Moulded zirconia articles should be burnt at 2,300 deg. or 2,400 deg. C., as mentioned. The burning is effected in a furnace provided with zirconia walls and a rotating flame fed with a blast of air or oxygen. Coal gas and oxygen easily give 2,400 deg. and 2,500 deg. C. in this furnace; with the aid of petroleum and oxygen temperatures of 3,000 deg. C. might be attained. Podszus has used such a furnace for 200 hours without essential repairs. Crucibles of pure zirconia will resist even fusing caustic alkalis for some time; the shrinkage of the burnt articles may amount to 20 per cent., however. Whether or not prolonged heating leads or

a partial reduction of the zirconia oxide to a black suboxide, as Ruff suggested, remains uncertain. We might mention another paper by Podszus on "Reaction Velocity and Grain Size" (*Zeitschrift für Physikalische Chemie*, 92, pages 227 to 237, 1917) on this occasion. He finds that burnt zirconia, thoria and alumina, which are considered insoluble in hydrochloric acid, become distinctly soluble when they are most finely disintegrated and heated to about 60 deg. C. with efficient stirring; after 40 hours 1.7 per cent. of zirconia, 1.5 per cent. of thoria and 5 per cent. of alumina were dissolved.

Spark Lengths in Gases and Vapours.

Although the electric discharge through gases has been the subject of many varied investigations, most of the experiments have been limited to the air and to the other constituents of the atmosphere, both the common and the rare. The discharge through hydrogen has especially interested the physicist and the radiotelegraphist; the chemist has studied rather the reactions accompanying the discharges through gases than their physical phenomena. Natterer determined spark-lengths in various gases in 1889 and found it difficult to co-ordinate the physical and chemical phenomena, as was to be expected. What is more or less ordinary temperature and pressure for the so-called permanent gases may be extreme conditions for vapours, and it is not easy to realise corresponding experimental conditions. Taking up these difficult researches a few years ago, Mr. Robert Wright, of the University of Glasgow (Transactions of the Chemical Society, 1917, pages 643 to 649), first attempted to compare vapours at their boiling-points with air at the same temperature; but he had to abandon this plan for several reasons, the condensation of vapours on the electrodes in the first instance. He therefore decided to keep the two spark gaps to be compared, of air and of the gas or vapour under test, at the same temperature, so as to have the same number of molecules per unit volume. That the spark-length depends on the number of molecules in the gap was understood. Heating a gas has no effect on the spark-leng h, provided the number of molecules per cubic centimetre be kept constant. Thus when the spark is produced in a closed vessel, the volts required to produce a spark are independent of the temperature; when the vessel is left open, so that the gas can expand, rise of temperature increases the length of the spark corresponding to a certain potential difference; lowering the gas pressure has the same effect as raising the temperature. Wright found in his experiments that a gap of 20 mm. at 100 deg. C. corresponded with a gap of 15 mm. at 18 deg., and a gap of 20 mm. at 183 deg. with one of 5 mm. at 18 deg. The electrodes of his standard air gap are brass spheres, 5 mm. in diameter, fixed on 3-mm. rods; they are adjustably mounted, with the aid of corks, in a vertical glass tube, 15 mm. internal diameter, surrounded by a vapour jacket. The tube containing the gas or vapour under test is similarly arranged, and the two tubes are electrically in parallel with an induction coil. There are, in fact, three spark gaps in parallel, the third gap serving for variation of the potential. At the beginning of an experiment this third gap is almost closed, and its electrodes are then moved apart until a spark crosses one of the other gaps. The apparatus had to be constructed so that it could easily be taken to pieces to clean the electrodes, especially when the vapours were decomposed by the sparks. The observed spark-lengths were not very concordant; differences of 10 per cent. and more were frequent, and the spark-length corresponding to a 20-mm. air gap was not two-thirds of the 30-mm. air gap, as it ought to have been, if the potential and spark-length curves were parallel. Carbon dioxide, *e.g.*, proved a better insulator than air at low potentials, but a better conductor at high potentials. On the whole, however, an increase of molecular weight was accompanied, in a series of comparable substances, by an increase in insulating power (decrease in spark-length). Thus methane CH_4, methyl chloride $CH_3 \cdot Cl$, methylene chloride $CH_2 \cdot Cl_2$, chloroform $CH \cdot Cl_3$, carbon tetrachloride CCl_4, gave, at 100 deg. C., with an air gap of 30 mm., sparks of 29 mm., 24 mm., 9 mm., 5 mm., 1.5 mm., respectively, and with an air gap of 20 mm. sparks of 20 mm., 16 mm., 6 mm., 3.5 mm., 1 mm. Similar figures were found for the halogen derivatives of ethane (the ethyl chloride, bromide, iodide), for homologous alcohols, and for substances like CO_2, SO_2, CS_2, H_2S.

The Sheet-Metal Industry.—Following the formation of a Joint Committee of Employers in the sheet-metal industry throughout the country, under the auspices of the National Employers' Federation, the first meeting has been held in London, under the chairmanship of Mr. H. E. D. Mabbott, of Messrs. Mabbott and Co., Limited, Poland-street, Manchester. Mr. Mabbott has been for some years chairman of the Lancashire Sheet Metal Employers' Association, and is well known in connection with the settlement of labour disputes.

Personal.—Mr. James A. Smith, M.Inst.N.A., naval architect and marine surveyor, informs us that he has removed his offices from 47, Leadenhall-street, E.C 3, to 1, Devonshire-square, Bishopsgate, E C.2.—Mr. J. E. Dobson, late Scottish representative of Bruce Peebles and Co., Limited, Edinburgh, has been appointed London office manager to the company in place of the late Mr. R. W. Gauntlett, and has now taken up his new duties at Hastings House, Norfolk-street, Strand.—The Right Hon. Lord Carmichael, G.C.I.E., K.C.M.G., has accepted a seat on the board of the British Thomson-Houston Company, Limited.

Honours to Naval Engineers.—The King has been graciously pleased to approve of the award of the following honours, among others, to navy engineers: (*a*) For services in action with enemy submarines. To receive a *Bar to the Distinguished Service Cross*: Engineer-Lieutenants L. S. Loveless and J. W. Grant. To receive the *Distinguished Service Medal*: Engine-Room Artificers F. Gazard, J. C. Edson and W. J. Hall. *Mentioned in Despatches*: Engineer-Lieutenant L. H. F. Young and Chief Engine-Room Artificer P. W. Dewsbury. (*b*) For service in submarines. To receive the *Distinguished Service Cross*: Artificer Engineers W. J. Williams and H. L. Smith. To receive the *Distinguished Service Medal*: Chief Engine-Room Artificers A. Smith, A. Phillips, A. W. C. Maggs and C. H. Doidge; Engine-Room Artificers J. Haddock, L. Adams, J. F. Apps, E. H. Hodgers, A. E. Tizard, L. V. Hauser, A. W. Savage, W. Mellish, G. L. Todman, E. F. C. Sutton, W. Plummer and T. G. Rogers. *Mentioned in Despatches*: Chief Engine-Room Artificers C. Mallalieu, W. Fletcher, A. H. Barnes, H. B. Sillick, J. Wilkinson, R. W. White, S. W. G. Herbert and C. S. Good; Engine-Room Artificers S. P. Pearce, A. McIntyre, J. J. Singleton, J. W. Kinder, J. F. Fraser, R. Dunwoodie, J. Hood, W. H. Midworth, H. Hambly, W. McQuade, F. J. Heath and A. J. Playle. (*c*) For miscellaneous services. *Mentioned in Despatches*: Engineer-Sub-Lieutenants J. H. Blackett, R.N.R., and R. C. Collins, R.N.R. (*d*) For services in the mercantile marine. *Commended*: Chief Engineers J. Duncan and W. E. Winter. The President of the French Republic has also conferred the *Croix de Guerre* upon the following: Engineer-Commander P. R. T. Brown, R.N., and Engineer-Lieutenant Commanders G. E. McEwen, R.N., W. Smith, R.N., and T. J. Foulkes, R.N.; also upon Engineer-Lieutenant R. G. Parry, D.S.O., R.N.

The British Industries Fair, 1918.—Next year's British Industries Fair, for which application forms for exhibiting space are now being issued by the Board of Trade, will be considerably larger than those of previous years. The last two fairs were held in the Victoria and Albert Museum and the Imperial Institute, and, though wonderfully successful, the space which was then available was by no means sufficient to meet the demands of the exhibitors. In many cases, in fact, exhibitors' applications for space had to be cut down by as much as 60 per cent., and the fact of the fair being in two buildings caused some inconvenience. The 1918 fair, which will, as usual, be open on the last Monday in February (February 25) and remain open for a fortnight, is to be held in premises which the Port of London Authority have been so good as to place at the disposal of the Board of Trade, and it is hoped that the available space will be sufficient to meet exhibitors' requirements, at any rate for this coming year, as the fair will, owing to the war, again be restricted to the following trades: Earthenware and china trade; glass trade; fancy goods trade; paper, stationery and printing trades; toy and games trade. The fact that the building for next year's fair contains about twice as much space as the Board was able to secure at the Victoria and Albert Museum is only one of its advantages. In the first place, it is more conveniently situated for business men, being near the Tower Bridge and only a few minutes' walk from Mark-lane Station on the Metropolitan and District Railways; and, in the second, the building is exceptionally well suited for the purpose of the fair, being a large roof-lighted warehouse on one floor. As in past years, invitations to the fair will be issued by the Board of Trade, and admission will be restricted to *bona-fide* buyers in the trades concerned. As the increased size of the fair and the growing shortage of labour will make the work of preparation exceptionally difficult, it is hoped that firms who are anxious to exhibit will send in their applications for space to the Director, British Industries Fair, 10, Basinghall-street, London, E.C. 2, at the earliest possible moment.

WORM GEARING.

To the Editor of Engineering.

Sir,—With reference to Mr. Bostock's paper on this subject, published in part in your issue of November 2, I am sorry to say that his argument about the "velocity of rubbing" is incorrect.

A reasonable definition of "velocity of rubbing" is as follows, in my opinion: "Velocity of rubbing is the velocity of a particle in one of the surfaces at the place of contact relative to a particle in the other surface at this place."

In the case of the worm and worm wheel all the particles of the wheel near to the worm are moving substantially at the pitch-line velocity of the worm wheel and parallel to the axis of the worm, and, in the case of the worm, all the particles touching the worm wheel are practically moving perpendicular to the previously mentioned motion and with velocity equal to the circular pitch-line velocity of the worm. The resultant of these two vector quantities gives a rubbing velocity equal to that which he mentions as the usually accepted one, and which he says may be three times greater than the true one.

I think that he has some idea that the motion of the place of contact renders a theory such as the above inapplicable, but I am quite certain that such is not the case, and that the usually accepted result is correct.

Yours faithfully,

Walter C. M. Pettingill, B.Sc.(Lond.).

Rochester, November 4, 1917.

DRAUGHTSMEN.

To the Editor of Engineering.

Sir,—One always reads with interest letters such as are now appearing in your columns on this constantly recurring subject. Writing with thirty-five years' experience in engineering works (ten of which were spent at the drawing board), and with other unique opportunities of sympathetically studying the draughtsman's lot, I venture the following submission. Draughtsmen are generally recruited from the industrial class, starting perhaps with a good board school education. They are, as a class, keen and studious to a degree in their profession, and by the time they reach 25 or 26 years of age very often possess an encyclopædic knowledge of engineering detail and method. But as a result of their concentration they have little knowledge of, often contempt for, things outside. Unlike the education of the medical or legal student, their training, in the technical school and within the close walls of the drawing office, robs them of opportunity for general culture and wide sympathy. How few of them can explain their ideas verbally (without the notorious pencil and note-book). How few can write a general report dealing with broad principles while avoiding unessential details. And still fewer can stand up before a meeting or board of directors and explain clearly the things they know so well.

I have often noticed that a draughtsman with an outside hobby, music, art, or literature, for example, goes ahead better than his colleague whose profession is his sole hobby, and this I think is because the former acquires broader views of life.

The natural conclusion would seem to be that draughtsmen of the future, if they wish to rank and benefit in proportion to their attainments, must come out of their shell individually and collectively. Some of us are sceptical as to the technical benefits claimed for academic courses now being planned, but there would seem to be no doubt that such courses will turn out better men, if not better draughtsmen.

Yours faithfully,

November 1, 1917. An Old Draughtsman.

To the Editor of Engineering.

Sir,—In the letter which appears in your issue of the 2nd inst., your correspondent "Senior Draughtsman," while referring to the general conditions of the employment of draughtsmen, makes himself responsible for the suggestion that the Association of Engineering and Shipbuilding Draughtsmen should definitely ally itself with Labour and become registered as a trade union. The brevity with which such a momentous proposal is put forward almost amounts to wit itself, and it is to be hoped that a great deal of earnest consideration and discussion will be given to this idea before any final decision is arrived at.

It must be conceded that the proposal for the association to become a trade union has a considerable amount of attraction for many draughtsmen, especially those who are of a spirited and pugnacious disposition; who apparently imagine that to become registered as a trade union is tantamount to claiming the liberty to enter into industrial strife at any and every conceivable opportunity—the oftener the merrier. This assumption is not quite correct. As far as my knowledge goes—and I am writing without reference—some trade unions are registered with the Registrar of Friendly Societies because by reason of such registration the union has greater legal advantages in respect of property held by it, and is entitled to certain exemptions from income tax on the returns from its invested funds; on the other hand, a registered union is put under obligations to the Registrar with regard to its constitution, rules and accounts, &c., from which unregistered unions are exempt. Not all trade unions are registered; in fact a considerable proportion have not availed themselves of this protection—which brings us to the conclusion that the difference between a trade union and any other organisation is purely constitutional, and is chiefly concerned with the allocation of funds. The suggestion that the association should become a trade union is therefore a proposal to

drastically alter its constitution, which is not to be passed over lightly.

At any rate it is worthy of more than a moment's consideration as to whether industrial strife, as a measure of securing the redress of grievances, has many advantages, especially in view of the fact that in the present circumstances the association is able to press its demands successfully without resort to such means. It may be taken for granted that a case which requires to be supported by a strike is a weak case to begin with, or, alternatively, is put forward by a weak organisation; and as the grievances of draughtsmen under the present dispensation are glaringly obvious, and the association of Engineering and Shipbuilding Draughtsmen, from the closeness of its ranks, may be counted as one of the strongest organisations, it may be reasonably assumed that draughtsmen will be able to obtain their rights without resort to such costly warfare.

Referring to the suggestion that draughtsmen should join forces with Labour, I take it that the term Labour as used by "Senior Draughtsman" refers to the Trade Union Congress or the Labour Party. On this assumption I am disposed to ask—with what purpose? It is not very clear as to what advantage will accrue to the draughtsmen's organisation by such an alliance. In the first place it must be borne in mind that just as draughtsmen hold a unique place in industry which places them on a different plane from the manual workers, so in industrial affairs they find themselves rather out of sympathy with the ordinary aspirations of Labour. Again, the above-mentioned bodies concern themselves mainly with national and social questions, on which draughtsmen as yet speak with no united voice, nor even concern themselves, even if it is considered desirable that they should do so. It appears that the intrusion of such matters into the deliberations of our local and general council meetings would lead to a considerable amount of disruption, and in any case would bring home little wool. On the other hand it may appear as a pleasing prospect, that in consequence of our alliance with the Labour Party that body would eventually nominate one of our officials as a Parliamentary candidate. As for that, I can only say that on the day when our future general secretary decides to neglect his legitimate duties for the task of winning the suffrage of a miscellaneous collection of men—and women!—some of us will seriously consider his position.

In conclusion I think it must be admitted that our policy of splendid isolation has much in its favour, and I certainly hope that it will be appreciated that the influence of the Association of Engineering and Shipbuilding Draughtsmen can and will be made to equal the influence of the much-envied British Medical Association and Law Society by the consolidation of our forces and the closing of our ranks, for these are the crux of the situation. For the rest, I think we are indebted to the founders of our association, who with such admirable foresight and judgment drew up the original constitution, which, while being comprehensive, has been subscribed to by so many members without conflicting with cherished personal opinions. Given men of equal ability in the future conduct of our affairs, an elevated status for draughtsmen will be established and maintained.

Yours faithfully,
FRED. H. AUGER.

Newcastle, November 5, 1917.

TO THE EDITOR OF ENGINEERING.

SIR,—As the writer of the first letter about draughtsmen and their treatment by some employers and the Government, in your issue of September 21, I am very gratified to notice that the opinions expressed in that letter have found several kindred spirits who think the same way on this subject as the writer, and your correspondent in your last week's issue from Manchester, strikes a very vital and important point. The association, although young, has secured for its members the same terms as for the men in the shops, viz., that all time-workers, draughtsmen included, shall participate in the 12½ per cent. wage advance. As, however, most draughtsmen are not paid by time, but at a standing rate per week, this award sounds more than it really means for the mass of draughtsmen, and it should be made the business of the Association of Engineering and Shipbuilding Draughtsmen to negotiate with the Ministry of Munitions that all draughtsmen are included in this 12½ per cent. bonus. We read in the official award, as published in the same issue at another place, two very striking sentences, which again show where the sympathies of the Government lie, and that the claim made by the Government that it looks after the interests of the employees in the same fair way as after that of the employers is not borne out by its actions during the past three and a half years and recent decisions. We read in the notice mentioned before: "That the Government is prepared to sanction firms granting this award to draughtsmen who are not on time rates, provided the necessary application is made by the employers." What about the draughtsmen who are employed with firms who refuse to make this application or, in fact, have resisted most strenuously all along any demand made by their staff for an increase due to the increased cost of living. I suppose the Government proposes to leave them in the hands of Shylock, with no fair Portia to deliver them. Further along we read: "It is also understood that the Ministry of Munitions is considering making a recommendation to employers that all the other draughtsmen beyond the purely time-rate men be granted this skilled workers bonus." Again I wonder whether the Government is going to stop at recommending such a course, which fairminded employers will no doubt act upon; but what about the black sheep amongst the employers; does the Government think these will act upon recommendations. All I can say from past experience is, that it is more than we can hope for. And I suggest that the Association of Engineering and Shipbuilding Draughtsmen should complete its good services for its members by getting from the Government the same terms of 12½ per cent. for its members employed at a standing salary as it has been able to arrange for time-rate men, and see to it that all firms are made to conform to these terms.

I remain, yours truly,
"DRAUGHTSMAN."

November 5, 1917.

TO THE EDITOR OF ENGINEERING.

SIR,—"Senior Draughtsman's" letter will have been hailed with much joy and pleasure by the majority of the members of the Association of Engineering and Shipbuilding Draughtsmen. The striking feature of his letter is that he has hit the nail on the head, in so far that he does not speak of grievances and bewail the ingratitude of the employers and the Government, but clearly sees and points out in no unmistakable language the weakness of his own organisation. It is essential that our association should be first of all a trade union, so that we shall be able to command respect and receive the support of the other engineering trades should we ever require their help.

We must not lose sight of the fact that we are workmen earning our daily bread at the board, and the sooner we drop the idea of being better than other grades of workers the better for all. By all means we must encourage the spread of knowledge by lectures and discussions, this of course being to the mutual benefit of all, as only those who have attended the lectures previously given can fully appreciate, but this must be a side line in our association's work and not its principal function.

I join with "Senior Draughtsman" in reminding our members of the approach of the annual meetings, and make an earnest appeal to all draughtsmen to attend, and not sit at home or perch themselves on their office stool grumbling and growling like a bear with a sore head that they cannot see what the association has done. We are the association, and have had twelve months in which to judge whether we are satisfied with our position; if we are, "'nough said"; if not, we must remember to bring our resolutions with us to the above meetings. Above all, let us not forget that the resolution for the main plank of our organisation must be registration as a trade union; and we must see to it that this be carried by an overwhelming majority, for the time is coming when all our strength will be required, and the sooner we cast aside the arguments of the purely "sloppy" educationalist, who will make a determined attempt to register us as an educational society, the better for all concerned.

I am, yours faithfully,
"YET ANOTHER SENIOR."

TO THE EDITOR OF ENGINEERING.

SIR,—It is announced that the War Cabinet have decided to adopt the Whitley Report as part of the policy which they hope to see carried into effect in their scheme of industrial reconstruction. The Minister of Labour has communicated to certain employers' organisations and to trade unions a long Memorandum on this subject.

According to this Memorandum it will be left to employers and trade unions to make their own regulations for controlling all conditions in their particular industries.

If the draughtsmen do not wake up they will find themselves out in the cold again. To avoid this they must first register as a trade union. Then they must make a working arrangement with the A.S.E. and other trade unions concerned, so that they may be in the strongest possible position to make their voices heard under the proposed new conditions.

In the various circulars of the Association of Engineering and Shipbuilding Draughtsmen great stress is laid on *status* and education, and in discussing the same with fellow-draughtsmen examples are given of doctors and lawyers. But what is the status of the briefless barrister or the doctor struggling with a poor practice worth? It is at once apparent that it is only income that counts.

The doctors, lawyers, dentists and other professional men charge fees, and themselves regulate those fees in their national or local associations, and will not work for less.

The unprofessional draughtsman, like the trade unionist, works for wages not fees, but, unlike the trade unionist, has not made any attempt to regulate his wages, and hence, in spite of the best qualifications, he has always, in the mass, been at the mercy of the employer.

In regard to the Association of Engineering and Shipbuilding Draughtsmen and educational lectures, there seems to be an inclination on the part of some members to compete with and overlap the work of the I.M.E., the I.E.E. and other established and worthy institutions. If the purpose is to keep the members interested in the Association of Engineering and Shipbuilding Draughtsmen, it has some value. On the other hand, if it is considered as a method of the association to increase wages collectively, it is valueless.

I remain, dear sir, yours faithfully,
"ANOTHER SENIOR."

November 5, 1917.

TO THE EDITOR OF ENGINEERING.

SIR,—I would not ask to trespass upon your space were it not for the fact that I feel the angle from which I propose to view the draughtsman's position will prove of particular interest to your readers. As a draughtsman I am subject to the ills that are so common to those who follow my craft, and realise, like the now big majority of them, that to be the only engineering craft that works individually is to be the worst off of the lot; but I wish to forget my personal ills and views, and to take a calm general survey of the situation.

Love as we may to dream of ideals and speak of morality, the fact remains we live in an age of stern business, so much so that, generally speaking, a company that sets out to practise philanthropy sets out merely to destroy itself. On the other hand—I take extremes in order to simplify reasoning—suppose a jobmaster, greedy for profit, starved his horses, do you think it would pay? If he wished to get the best out of them it surely would not; yet the draughtsman's position is much like this to-day.

Draughtsmen require more than food for the body if they are going to do justice to their craft—they require food for their brain. Popular science series of books are quite cheap to-day; but technical books cannot be published under something like six times their price, not only because of the additional care they necessitate in production and the research they require, but because the number sold is so much smaller. What is true of text-books is perhaps as true of technical periodicals. One often wonders what we really should do were it not for the fascination there is to be found in research, and the men who work for it and write for the mere pleasure they derive, with perhaps some well-earned respect.

While, perhaps, in spite of the war, draughtsmen do not lack food, I feel it would be not untrue to say the feeling of insecurity, the constant struggle to make ends meet, often blunts their edges; particularly is this true in the case of the married men, and it would be even more marked were it not for the fact that men seem naturally to narrow down their sphere of outlook and concentrate on their work when they become married.

In view of what has been said it will readily be seen that it is not only advantageous to the master to give draughtsmen fair wages and short hours, but it is advantageous for them to acknowledge the association, because it will not then rest on individual philanthropy, but the sense of the masters' federation. Speaking for my class, I feel a federation can always view a position in a broader and less short-sighted manner than an individual master can.

Were I not of the craft, I could write glowing accounts of the functions we have fulfilled during the war—and what craft has not?—and I feel that with its finish the technical man will be more than ever necessary. Technical education and research are of acknowledged national importance, and I contend that the care of the technical worker is just as important. Remember, the love of craft springs from a contented mind. Relieved of the worry to live, work becomes man's chief pleasure, and he finds life worth living; it is not until then that you can tell of what a man is made. Trusting I have fulfilled to some extent that which I set out to fulfill,

I remain, yours truly,
ALBERT INSTONE.

25, Duncombe-road, Hornsey Rise, N. 19,
November 3, 1917.

THE JUNIOR INSTITUTION OF ENGINEERS.—The annual report of the Council of the Junior Institution of Engineers shows that 117 new members were elected during the year, and that the total roll call numbered 1,329 on September 30 last. Three members and four associates were killed in action during the year. The Institution has now arranged for the establishment of a class of "cadet associate members," to consist of first and second-year apprentices or engineering students. A series of lectures on works management promises to be an interesting item in the programme of the new session.

THE NEW BRITISH BATTLE CRUISERS.—We read in *The Times* that Mr. A. Rousseau, the military critic of *Le Temps*, who has just returned to Paris from visiting the Grand Fleet, has been permitted by the British Admiralty to give French readers the first description of our new battle cruisers. Among the vessels which the French expert saw were some which caught his attention especially, owing to their outline and dimensions. They were very long, with immense decks fore and aft. They appeared to lie low on the water, but perhaps this was an optical effect produced by their length. In the middle of the vessel rises a very squat central castle, at the extremities of which are the heavy artillery turrets, turrets for two guns of the biggest calibre. The shape of the stem has been determined in order to realise a very high speed, and as a matter of fact, these vessels are very swift, much fleeter than the fleetest of pre-war cruisers. These vessels have been erected since the war. They were begun in 1915 and have been 12 months in service. Other vessels of the kind are under construction, their dimensions being yet more considerable. Everything in the new ships is organised to have the fire control in one and the same hand, and the laying by one and the same eye. The system invented by Admiral Sir Percy Scott a few years ago has made great progress. The heavy artillery and the secondary artillery are no longer autonomous; everything acts under one and the same direction. It is a truly remarkable system and one which, beyond all doubt, has produced highly satisfactory results. Its installation on the new ships shows that it has stood the test. The ships are a proof of the confidence of the British Navy in the powerful surface vessel, capable of heavy hitting, the only one which appears able to assure the mastery of the seas. "England is building many submarines," adds the French expert, "but the development of this new weapon has not affected the theories which have made the naval power of our Allies, and this is proved by the new building programmes, which are the outcome of experience."

WORM GEARING.*

By Francis J. Bostock, A.M.I.Mech.E., A.M.I.A.E., Huddersfield.

(*Concluded from page* 480.)

Manufacture.—In ordinary machining one is dealing with plane or circular surfaces, but in worm gear one has to manufacture curved helical surfaces, which is, without doubt, a most difficult manufacturing operation to carry out. It will be readily understood that as an error of one-thousandth part of an inch prevents two like surfaces from touching, an error of only that amount will materially alter the contact bearing between the gears. The difficulty in eliminating that one-thousandth is enormous, especially when it is necessary to make several thousand gears absolutely interchangeable: therein all the curved surfaces have to be identical.

With your permission the author wishes to show you how such interchangeable curved surfaces are made, and in doing so he will be describing the methods and processes carried out by Messrs. David Brown and Sons (Hudd.), Limited, Huddersfield, with whom the author has pleasure in associating himself. The whole of the machines and appliances to be shown have been designed and built by the firm to enable them to produce large quantities of interchangeable work with rapidity and accuracy.

Worm Milling.—The worms are usually supplied solid with their shafts and are supported in their cases by two ball journal or plain bearings, placed on either side of the thread. In order to guarantee concentricity and uniformity of size a practice is made of grinding all worms on the outside diameters of the threads and journals before the cutting operation.

The worm-milling machine, illustrated in Fig. 7, consists essentially of three main castings—the bed, head and horizontal table. The bed is T-shaped, and provides ample bearing surface for the sliding table and head. This well-proportioned head slides at right angles to the work, is extremely rigid, and after being fed to the correct depth, measured by a micrometer, the worm is caused to travel spirally in front of the cutter, thus milling a thread space for each longitudinal travel of the table. The cutter spindle is carried in a swivelling cover, which enables it to be set at any angle to suit the spiral of the worm to be cut. A very special feature of this construction is the manner in which objectionable overhang, so common in other machines, has been overcome. This eliminates vibration during cutting.

The table is of unique design, being supported in an exceptionally long V-slide forming part of the bed, so arranged that all stresses and thrusts due to cutting are properly taken care of, and that it can smoothly traverse the bed, even under the heaviest of loads. It carries on the right-hand extremity a patent collet chuck and dividing head, whilst a self-centring roller steady can slide along its surface.

The main drive is from a single pulley, which is provided with an internal friction clutch operated by a lever situated in front of the machine. After passing through a four-speed gear-box the drive separates, in one case passing through mitres to the cutter head and in the other case through a feed gear-box, automatic trip gear, and change gears to the lead screw; at the same time, by passing to the dividing worm and wheel, slowly rotating the work past the cutter at the requisite lead. As the drive is designed to pass through an index plate to the dividing worm, it renders it a simple matter to index the worm to the required number of threads.

The worm is carried in the special collet chuck, which is made from hardened and ground high-tensile steel. The operating mechanism consists of an outer sleeve, which is conical at one end to receive the collets, the other end being screwed to suit a hand wheel and slotted to accommodate two toggle levers. An inner sleeve engages at one end with the collets, and is, at the other end, adjustable in its length by means of a screwed sleeve and a smaller hand wheel. This hand-wheel sleeve, which gives preliminary adjustment, is fitted with a hardened steel washer, against which the toggles bear, so that when the large hand wheel is screwed along its sleeve it causes the toggles to press against this washer, thence to the work, so gripping it with an immense increase in leverage. The operation of tightening or releasing the work requires but a few moments. The work being truly gripped at one end, is supported at the other end by means of a sliding adjustable self-centring roller steady, which enables it to be firmly held, at the same time giving entire freedom of rotation.

Cutter Form Generation.—The rotary worm cutter at first sight appears to be quite a straightforward matter, with its contour made to correspond with the space of the worm thread. Such, however, is far from being the case, as its actual contour is quite different from the thread space which it cuts in the worm blank, as can be readily observed in Fig. 8. This apparent paradox is caused by the interference of the cutter with the sides of the worm threads, and will be readily understood

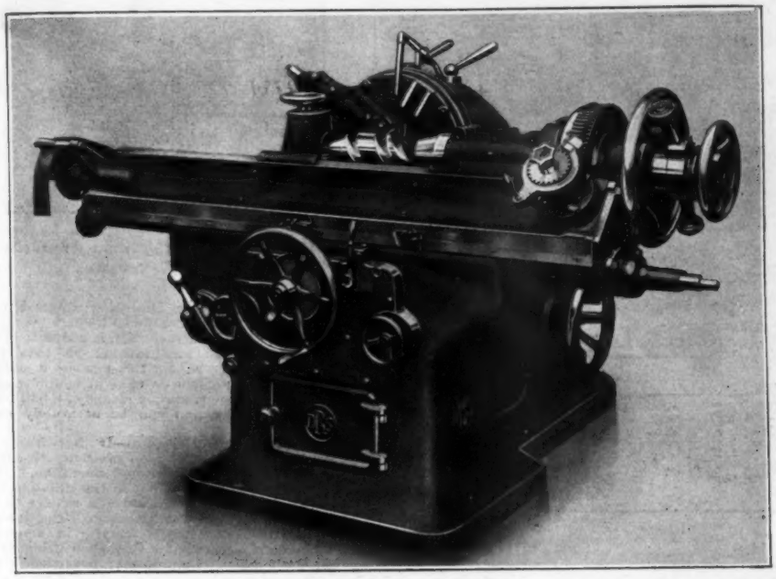


Fig. 7. Worm Milling Machine.

Fig. 8. Worm and its Cutter.

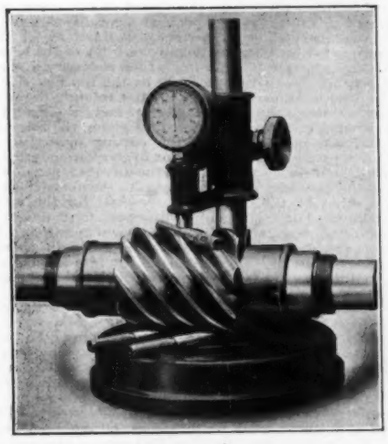


Fig. 9. Gauging a Worm for Pitch Diameter.

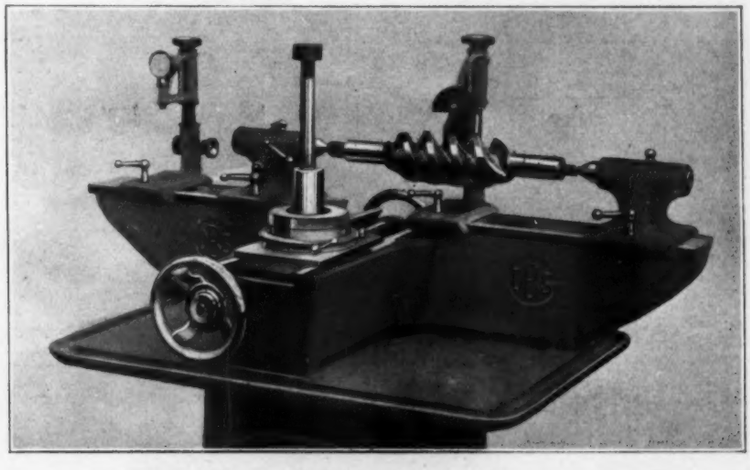


Fig. 10. Testing Worm for Accuracy of Pressure Angle.

* Paper read before the Manchester Association of Engineers on October 27, 1917.

when it is remembered that the worm thread is an endless spiral; hence if the cutter were to fit exactly the thread space it would likewise have to be made spiral in shape, which would be an absurdity, for it would no longer revolve. As a rotary cutter must be made circular in shape, and as a circle and a spiral cannot coincide, it is obvious that the contour of the circular cutter cannot coincide with the thread space of the spiral worm.

It will be remembered that the base of the worm thread system is a straight line. In the system of cutter generation a straight-edged tool is set to an angle corresponding to the pressure angle of the worm to be cut, and is then made to traverse in a spiral path corresponding exactly with the spiral of the worm. Thus a generating tool is mounted in a worm-milling machine in the same position and manner as the worm which has to be cut, its straight edge accurately representing one side of the worm thread. When it has generated one side of a white metal blank it is indexed to the other side, thus forming the contour of the required cutter.

Worm Inspection.—The usual method of gauging gear teeth is by means of gear-tooth calipers, which whilst being satisfactory for ordinary measuring purposes, are too slow and not sufficiently accurate for quantity production. All measuring devices should be quick in action and show a magnification of the error, thus enabling the smallest discrepancy to be made easily apparent. Instead of the gear-tooth calipers a bench instrument, like the one shown in Fig. 9, is used; two suitable bars are placed under the worm and a third is placed on the top, the worm is then rolled under a clock indicator, a reading of two-thousandths of an inch indicating an error of less than one half-thousandth in tooth thickness.

For testing the accuracy of the pressure angle a knife-edge protractor is placed along the side of the thread and the angle read to plus or minus a few minutes. This is carried out in a worm-gear testing machine, illustrated in Fig. 10, which has been designed to enable the various testing operations to be performed on both worms and wheels. These can be tested separately as individual pieces, or in combination when mounted together at the specified centre distance. The bed consists of two slides at right angles, one carrying a pair of adjustable centres and the various testing appliances, whilst the other slide carries an adjustable arbor adapter, which is controlled by a micrometer screw, enabling it to be set at any required distance from the other slide, so giving correct centres for the worm and wheel under test. This machine is most conveniently operated, as it can be worked from either side, thus allowing the operator to be in the most advantageous position to carry out all the necessary tests. Other instruments are used on it for testing concentricity and lead.

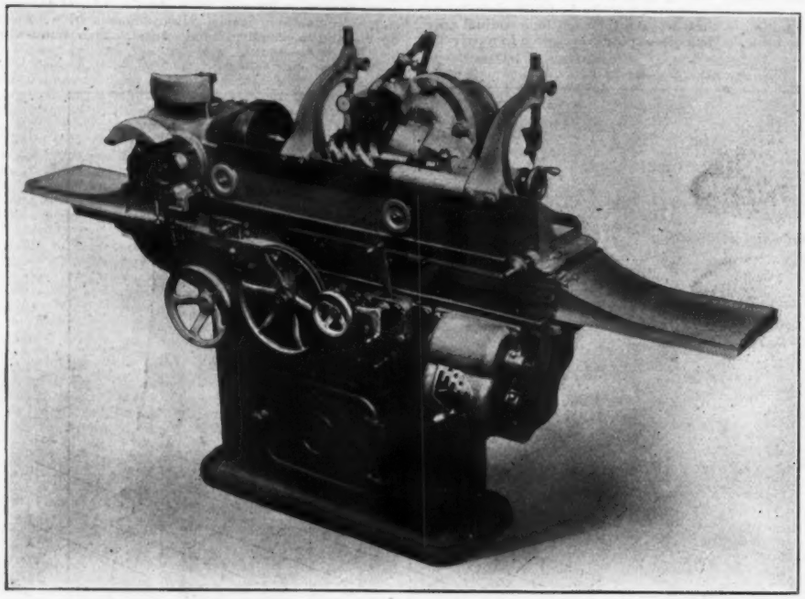


FIG. 11.

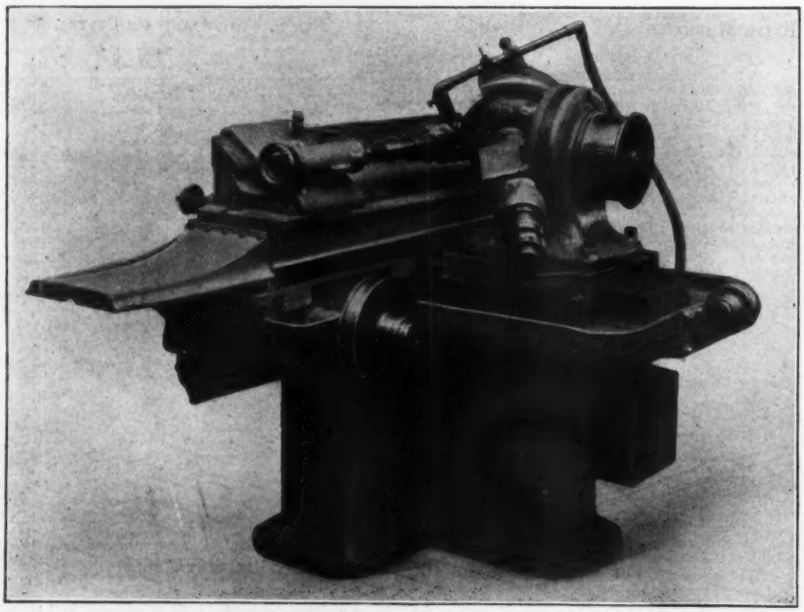


FIG. 11A.

FIGS. 11 AND 11A. WORM GRINDING MACHINE WITH ITS MEASURING INSTRUMENTS.

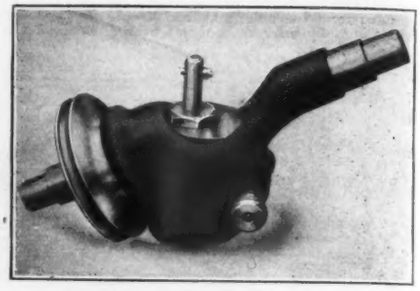


FIG. 12. WORM GRINDING ABRASIVE WHEEL GENERATOR.

The process of case-hardening worms is exactly the same as for other work, but although every precaution be taken, some little distortion is bound to occur. They therefore require straightening so that their pitch diameter runs true; for this purpose a clock indicator on a testing machine is used in conjunction with the straightening press, and by means of a ball placed in the space this operation can be accurately and quickly performed.

Worm Thread Grinding.—It has been previously mentioned that it has been necessary to design special machines for each individual operation. The various movements to be executed in the grinding of a multi-threaded worm are intricate and require to be carried out with the greatest precision. The ideal machine should, of course, be automatic in action, but the designing of a machine to fulfil such stringent conditions is a most difficult proposition; nevertheless it has been accomplished, with entirely successful results.

The general lines of this machine are based on the best modern practice of up-to-date cylindrical grinders, as will be noted in Fig. 11. The abrasive wheel is mounted upon a universal head, and is of large diameter, its shape being generated by a patent diamond generating device. The wheel is so mounted that it can be easily placed in the best position relative to the thread of the worm, with regard to the spiral and pressure angles, thus enabling a large diameter to be used without interference. The worm is caused to travel spirally in front of the wheel; the change gears, in order to give the necessary lead and index, are situated respectively at the top and side of the fixed head, and the motion, after rotating the work, passes through the lead change gears and the differential, so driving the lead screw nut, thus giving the necessary spiral movement. During the cutting operation the motion passes through a gear-box to give various grinding speeds, but for the quick return the drive is taken direct; and the mechanism is so connected to the abrasive wheel slide that at the moment of reversal for the return stroke the latter is rapidly withdrawn from the work, and at the end of its travel it slowly approaches the worm thread, ready for the next cut. During the quick return stroke the differential comes into action and causes the worm to be automatically indexed to the next thread.

The machine is so designed that the worm is revolved on fixed centres, the top table being also pivoted to provide for the correction of parallelism. An easy movement of the handles gives instant setting to suit either a right or left-hand worm. The whole of the operating hand wheels and levers are situated in front of the machine in a most accessible position. The simple movement of a lever automatically arrests, at the end of the next quick return stroke, all the movements of the machine, thus enabling the operator to gauge the work that is being ground. After gauging, the machine is ready to commence the next cutting stroke, it being only necessary again to move the above lever, when the cycle of operations is once more resumed.

One has already observed how it is necessary for the worm-milling cutter to have its contour generated, and this is with a cutter diameter of only 5 in.; how much more so is it not imperative to generate the cutting surface of a 12-in. diameter abrasive wheel? This is accomplished by an abrasive wheel generator which is placed in the machine in the same manner as the worm to be ground, the machine itself being geared or set up according to the specification of the worm. From Fig. 12 it will be seen that this consists of a cast-iron body which carries a reciprocating diamond set to travel at the required pressure angle and situated exactly upon the centre line of the system; hence it follows that its movement corresponds to a line on the worm face, so that when it is caused to reciprocate at the same time as it traverses spirally across the face of the wheel, it will give to the latter just that particular shape which will in turn grind the worm with the correct shape of tooth.

The work is fed laterally to the face of the wheel,

KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(*For Description see Page* 485.)

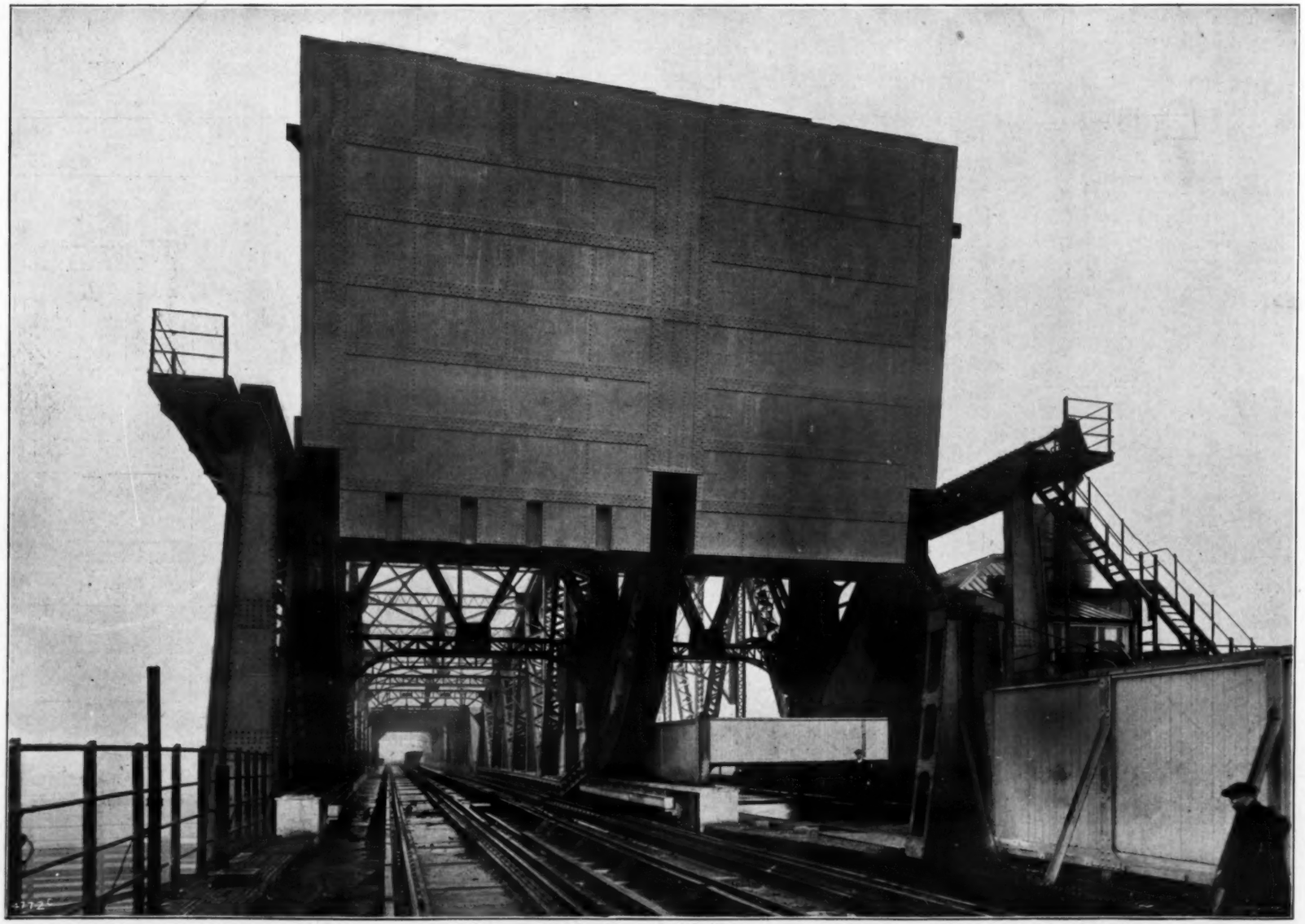


FIG. 44. VIEW OF ROLLER LIFT SPAN WITH COUNTERBALANCE BOX.

(*To face page* 484.)

THE KEADBY SCHERZER ROLLER LIFT BRIDGE; DETAILS OF COUNTERBALANCE BOX.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(For Description see Page 485.)

Fig. 45.

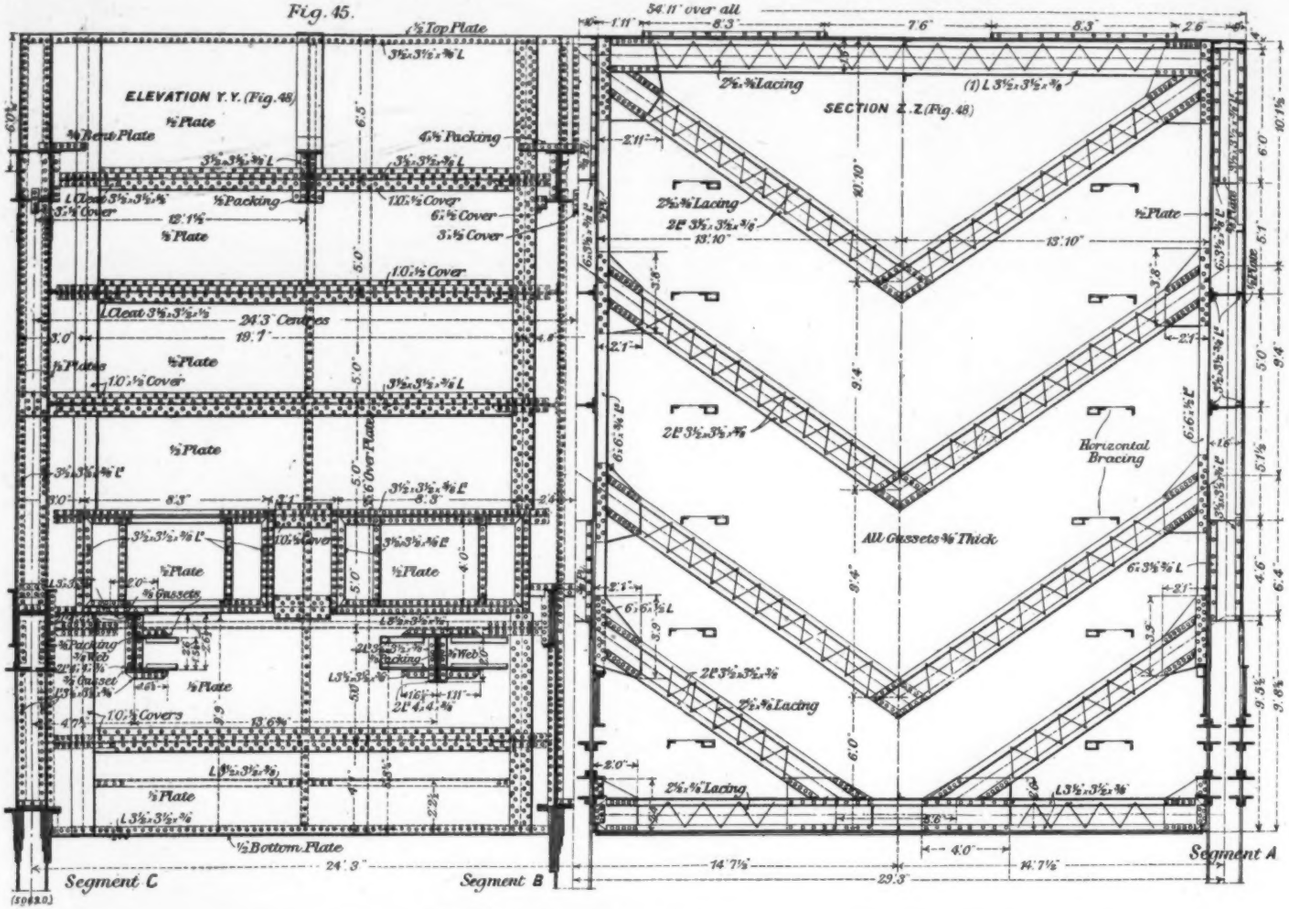


Fig. 46.

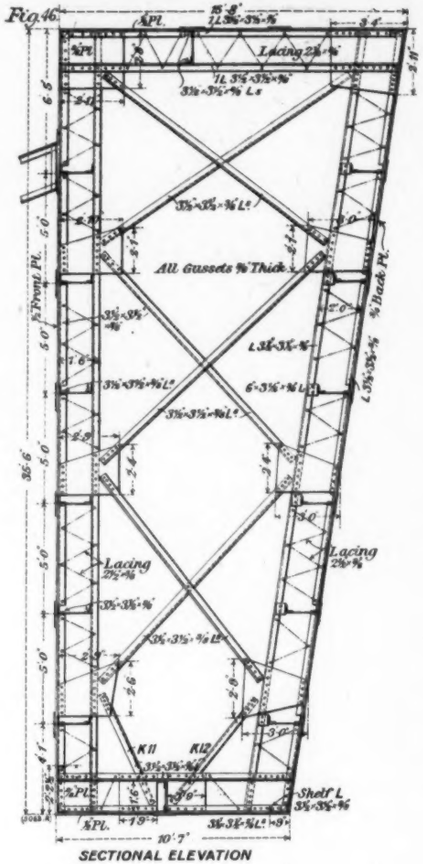
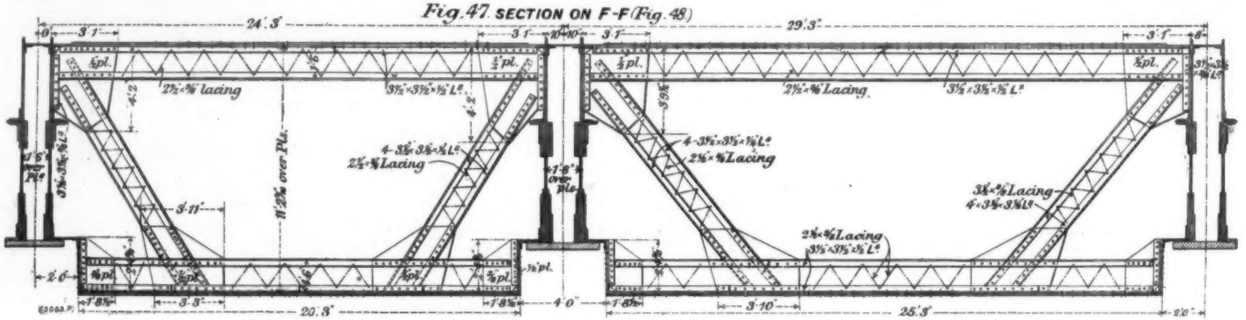


Fig. 47 SECTION ON F-F (Fig. 48)



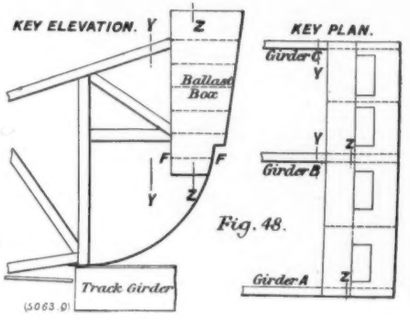


Fig. 48.

THE KEADBY ROLLER LIFT BRIDGE; DETAILS OF TRACK GIRDER.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(For Description see Page 485.)

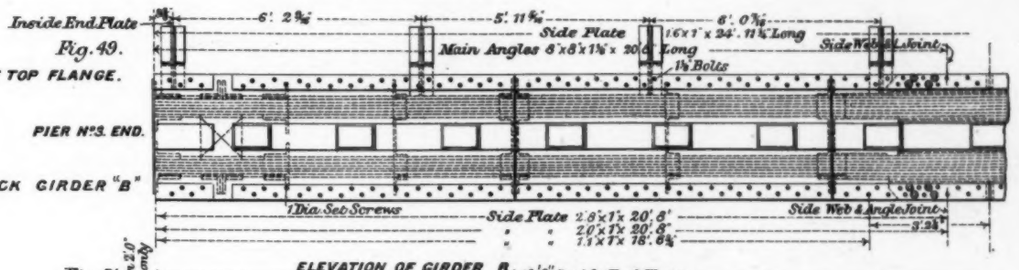

Inside End Plate
6'. 2⅝"
5'. 11⅝"
Side Plate
1.6 x 1' x 24'. 11⅛" Long
6'. 0⅞"
Main Angles 8" x 8" x 1⅛" x 20'. 6" Long
Side Web & Angle Joint
1⅛" Bolts
PIER No 3. END.
CENTRE TRACK GIRDER "B"
1" Dia. Set Screws
Side Plate 2.8" x 1" x 20'. 8"
" " 2.0" x 1" x 20'. 8"
" " 1.1" x 1" x 16'. 6½"
Side Web & Angle Joint
3'. 2½"

Fig. 49. PLAN OF TOP FLANGE.

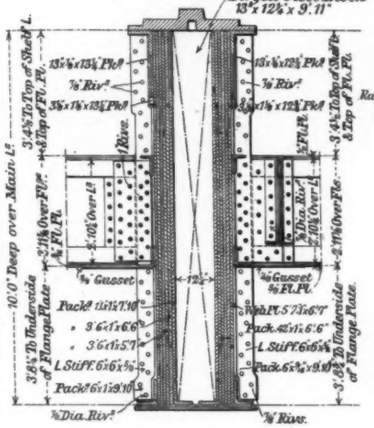


Fig. 50. SECTION AT B.B.

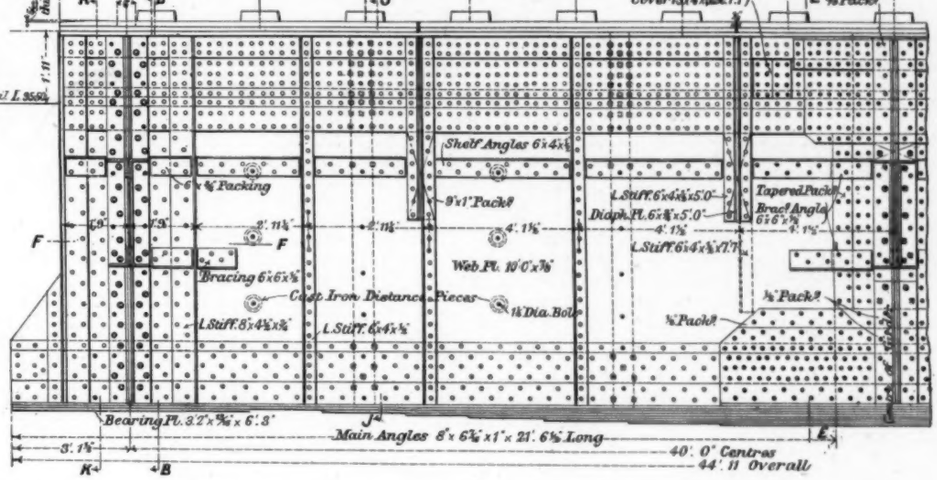

ELEVATION OF GIRDER B
43'. 6" Inside End Plates
20'. 0" Centres of Girders
Level in 2'. 0" this end only
Cover 13⅝" x 11⅝" x 1'. 1"
Rail L 95 lbs.
Shelf Angles 6" x 4" x ⅝"
⅝" Packing
9" x 1" Packg
Tapered Packg
Bracg Angle 6" x 6" x ⅝"
L. Stiff. 6" x 4" x ⅝" x 5'. 0"
Diagh. Pl. 6' ⅛" x 5'. 0"
L. Stiff. 6" x 4" x ⅝" x 1'. 7"
Bracing 6" x 6" x ⅝"
Cast Iron Distance Pieces
1⅛" Dia. Bolt
Web Pl. 10'. 0" x ⅜"
L. Stiff. 8" x 4" x ⅝"
L. Stiff. 6" x 4" x ⅝"
½" Packg
Bearing Pl. 3'. 2" x ⅝" x 6'. 3"
Main Angles 8" x 6" x 1" x 21'. 6" Long
40'. 0" Centres
44'. 11" Overall

Fig. 51.

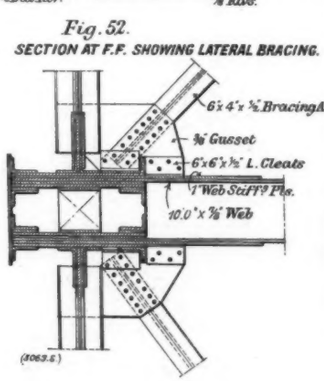


Fig. 52. SECTION AT F.F. SHOWING LATERAL BRACING.

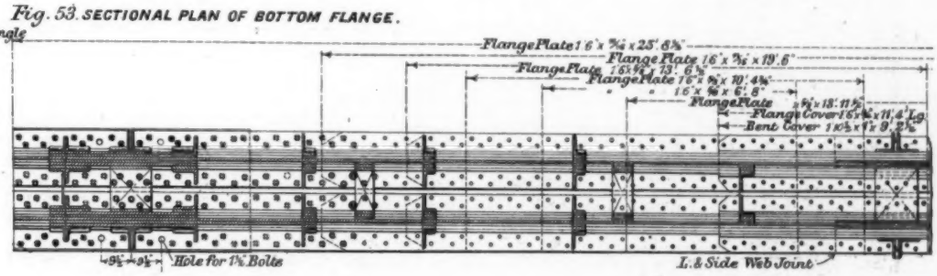

Flange Plate 1.6 x ¾ x 25'. 6"
Flange Plate 1.6 x ¾ x 19'. 6"
Flange Plate 1.6 x ¾ x 13'. 6"
Flange Plate 1.6 x ⅝ x 10'. 4"
" " 1.6 x ⅝ x 6'. 8"
Flange Plate 2 ½ x 18'. 11"
Flange Cover 1.6 x ⅝ x 11'. 4" Lg
Bent Cover 1½ x 1' x 9'. 2"
9½" 9½"
Hole for 1⅛" Bolts
L. & Side Web Joint

Fig. 53. SECTIONAL PLAN OF BOTTOM FLANGE.

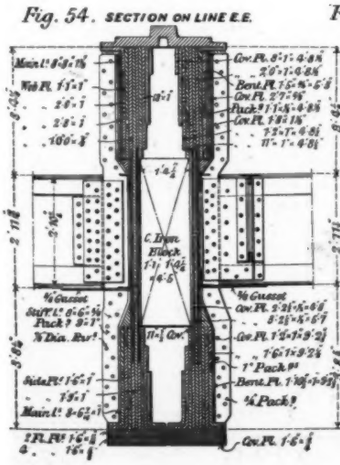

Main L 8" x 8" x 1⅛"
Web Pl. 1'-1"
Cov. Pl. 8'-1" x 4'-8"
2'-6" x 1'-6" x ⅝"
Bent Pl. 1'-6" x ⅝" x 5'-8"
Cov. Pl. 2'-7" x ⅝"
Pack 1'-1" x ⅝" x 4'-8"
Cov. Pl. 1'-8" x 1⅛"
7'-7" x ⅝" x 6'-8"
11'-1" x ⅝" x 4'-8"
C. Iron Block 1'-1" x 1'-0" x 1'-6"
⅝" Gusset
Stiff L. 6" x 6" x ⅝"
Pack 9" x 5'-7"
⅝" Dia. Rivs
Side Pl. 1'-6" x 1"
1'-6" x 1"
Main L 8" x 6" x 1"
2 Fl. Pls 1'-6" x 1"
1'-6" x 1"
Cov. Pl. 1'-6" x ⅝"

Fig. 54. SECTION ON LINE E.E.

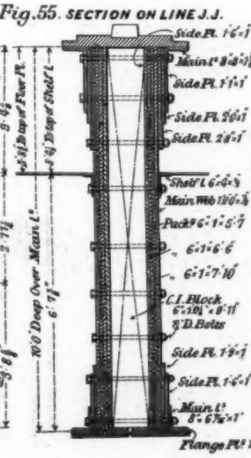

Side Pl. 1'-6" x 1"
Main L 8" x 8" x 1⅛"
Side Pl. 1'-1" x 1"
Side Pl. 2'-6" x 1"
Side Pl. 2'-6" x 1"
Shelf L 6" x 4" x ⅝"
Main Web 10'-0" x ⅜"
Pack 6" x 1'-5" x ⅞"
6" x 1'-6" x 6"
6" x 1'-7" x 10"
C.I. Block 6" x 1'-8" x 9'-11"
1⅛" D. Bolts
Side Pl. 1'-6" x 1"
Side Pl. 1'-6" x 1"
Main L 8" x 6" x 1"
Flange Pl 1'-6" x ⅝"

Fig. 55. SECTION ON LINE J.J.

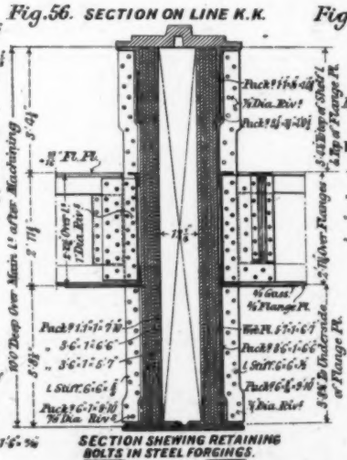

Pack 1'-1" x 1'-1" x ⅝"
⅞" Dia. Rivs
Pack 1'-1" x 1'-1" x ⅝"
Web Pl. 5'-7" x 6" T
3'-6" x 1'-6" x 6"
3'-6" x 1'-5" x 7"
L. Stiff. 6" x 6" x ⅝"
Pack 6" x 1'-9" x ⅞"
⅞" Dia. Rivs
⅝" Gusset
½" Flange Pl.
Web Pl. 5'-7" x 6" T
Pack 8" x 6" x ⅝"
L. Stiff. 6" x 6" x ⅝"
Pack 6" x 6" x ⅝"
⅞" Dia. Rivs

Fig. 56. SECTION ON LINE K.K.

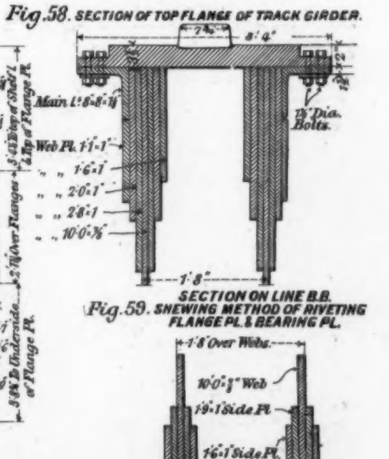


Fig. 58. SECTION OF TOP FLANGE OF TRACK GIRDER.

SECTION ON LINE B.B.

Fig. 59. SHEWING METHOD OF RIVETING FLANGE PL. & BEARING PL.

SECTION SHEWING RETAINING BOLTS IN STEEL FORGINGS.

Fig. 57.

THE KEADBY SCHERZER ROLLER LIFT BRIDGE; LIFTING SPAN.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(*For Description, see Page* 485.)

FIG. 60. VIEW OF FIXED SPANS AND ROLLER LIFT SPAN RAISED.

(*To face page* 485.)

hence the contour remains constant during the grinding operation. After one side has been done the worm is turned end for end, and the other side ground in like manner. The machine is fitted with measuring devices for the purpose of verifying the work during grinding operations.

tion of the worm, with which the wheel will have to mesh. Whilst it is true that the spiral angle, pitch, number of threads, and pitch diameter must correspond exactly with that of the worm, yet both the outside and bottom diameters are made larger in order to provide requisite clearance in the roots of the teeth. There is a still

supervision in all the stages of its progress, because when finished it is extremely difficult to examine it without cutting a wheel, and so verifying the shape by means of a worm. No matter how perfectly one may make a hob, unless it be sharpened with a corresponding degree of accuracy and precision the original object is

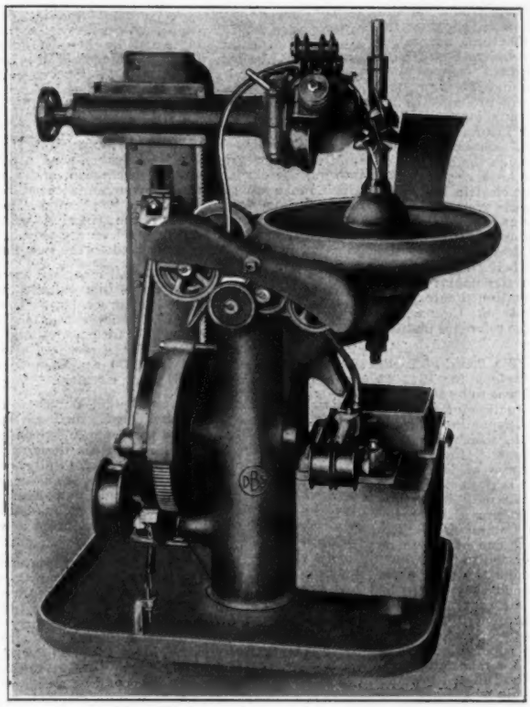


FIG. 13. HOB SHARPENING MACHINE.

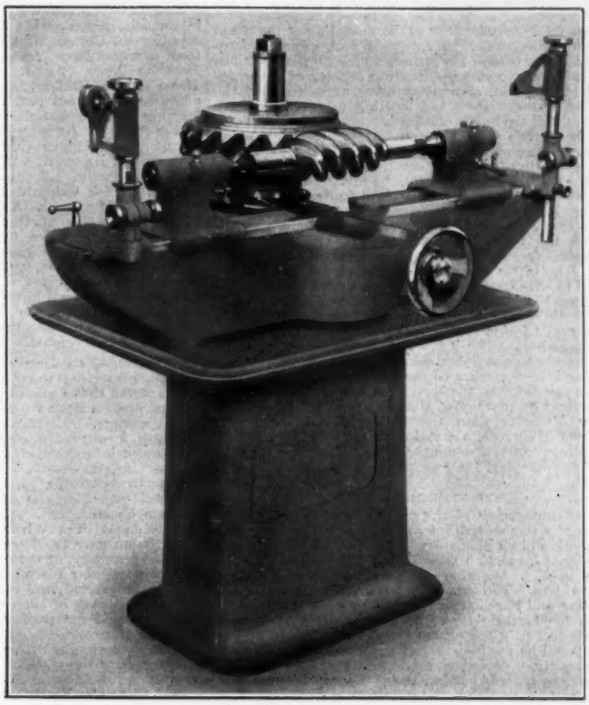


FIG. 15. WORM GEAR TESTING MACHINE.

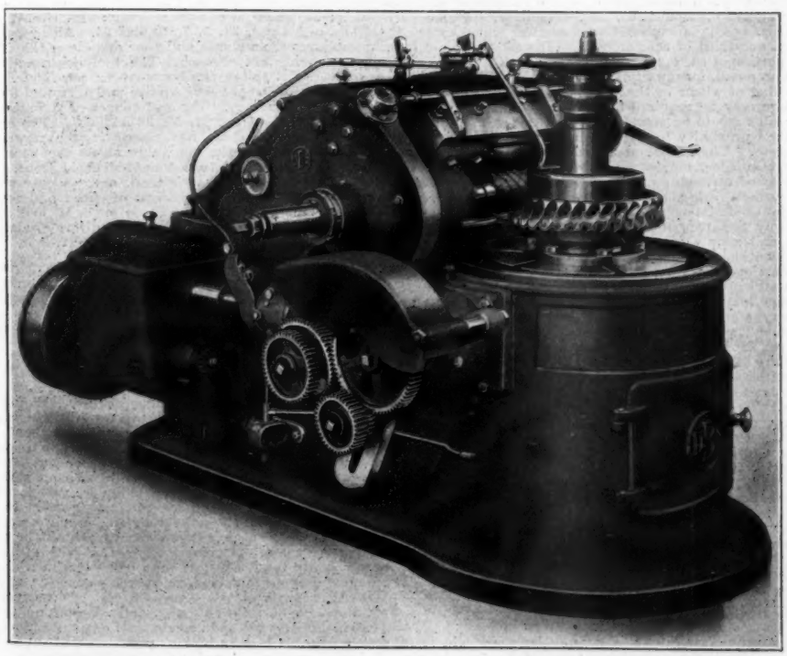


FIG. 14. WORM WHEEL GENERATOR.

Hobs: Manufacture and Sharpening.—The teeth of worm wheels are of such construction that they do not lend themselves to operations of planing, shaping or milling like other forms of gearing, and can only be produced by a process of generation by means of a cutting tool called a hob.

At first glance the hob would appear to be a reproduc-

further difference in that the hob thread is gashed along its length normal to the spiral angle for the purpose of providing a cutting face, whilst the sides of the teeth are relieved in order to provide a cutting clearance.

As the shape and contour of the wheel teeth are entirely dependent upon the design and accuracy of the hob, it is necessary that this tool should receive the most careful

quickly defeated, rendering it useless for first-class production. It has therefore been found necessary to design and build a special machine for the purpose of sharpening hobs and cutters.

The general lines of this machine will be apparent from Fig. 13. It consists essentially of a column carrying a ram slide, the latter carrying, at right angles, the abrasive wheel slide. The hob or cutter to be ground is mounted vertically on a suitable holder, which is centrally situated in a circular water basin, which in turn is fitted to the bed of the machine. The abrasive wheel is mounted upon a universal head, which can be rotated at an angle to suit the lead of the gashes of the hob, and is driven from an overhead countershaft by means of round leather belting.

The ram slide is reciprocated in a vertical direction, thus causing the abrasive wheel to traverse the length of the hob, the latter having given to it by means of change gears the requisite rotation to give the required spiral movement. The machine is so designed that the return stroke is at a higher velocity than the cutting one, and the depression of the operating pedal causes it to stop at the top of its next up or return stroke. The indexing is accomplished by means of a dividing plate, in conjunction with which is a fine adjustment for obtaining the feed or cut.

Hobs are generally made with their cutting faces radial; it is therefore necessary that they be sharpened radially, or an alteration in shape will result. The same of course applies to ordinary rotary cutters. In order to accomplish this an abrasive wheel generator is placed in the machine instead of the hob. In this generator the diamond reciprocates radially, so that when it traverses the face of the abrasive wheel it removes that interference which would prevent the wheel from cutting a radial face. This interference is very great, and the resultant shape is a peculiar curve which varies with every hob, position and diameter of wheel.

It will be readily seen that as a hob is sharpened its diameter is reduced, but with a reamer hob the reduction in diameter is only a few thousandths of an inch in the whole length of the tooth; thus uniformity of shape is obtained. Most of the hobs are made from high-speed steel, many of which are ground on the threads after hardening.

WORM WHEEL GENERATING.

Generally the worm wheels are rough-turned on automatics and turret machines, and pass from thence to the worm-wheel section for rough cutting of the teeth, after which they are finish-turned, and finally the teeth undergo a reamering or finishing operation. In no small measure is the interchangeability and high efficiency of the wheels due to this reamering operation.

The generating of the teeth of the worm wheel is carried

out in a machine as illustrated in Fig. 14, the blank being mounted upon a revolving table, which is positively driven at a predetermined speed, according to the ratio of the gears being cut, whilst the hob is caused to travel longitudinally across the face of the wheel. Owing to the spiral of the hob it is necessary to compensate for its longitudinal travel by means of a differential, whilst the rate of travel or feed can be varied at the will of the operator.

A special feature is made of the mounting of the worm wheel on the table. A hardened and ground micrometer adapter carries the arbor, which supports various other adaptors to suit the locating register of the worm wheel blanks, the micrometer being adjusted until the specified distance from the locating face of the blank to the axis of the hob is obtained.

To facilitate setting up, and to test the true running of the registers and worm wheel blank, the drive to the table is arranged so that it can be disconnected in order that the operator may be able to revolve the table by hand and so, by means of a clock indicator, test the accuracy of the mounting.

The head, which slides horizontally along the bed towards the worm wheel, contains the whole of the mechanism for driving the hob and traversing the hob slide. The latter is mounted on the head at an angle normal to the direction of the stress, so as to present the maximum bearing area to the very best advantage.

The main drive is taken from a single pulley fitted with an internal friction clutch in conjunction with a four-speed gear-box. The drive is then transmitted in one case directly to the index change wheels for driving the table, and in the other to the worm wheel mounted on the hob spindle.

It should be mentioned that the dividing wheel is of greater diameter than the largest blank which the machine will cut, and a neat design is effected by allowing the cuttings to fall through the arms of the table into the bed of the machine, from whence the cutting lubricant is drained.

Inspection and Testing.

Interchangeability of the worm wheel is ensured by the use of a double ball micrometer, which measures the comparative pitch diameters.

The final inspection is made on the testing machine shown in Fig. 15, where the work undergoes a more rigorous test. The wheels are tested for concentricity of cutting and the distance from the centre of the worm axis to the locating face, after which they are tested together to verify the centre distance. From the foregoing it will be realised that the system of manufacture and inspection described enables the worms and the wheels to be regarded as independent components, hence facilitating production and duplication.

Turning now to the application of worm gearing: in many cases the contracts for reducing gear units specify that prior to despatch they shall undergo to the satisfaction of their engineer running tests as near as possible to the actual service conditions, during which tests various observations and readings are taken to determine the satisfactory running of the gears.

Some time ago, in order to ascertain the efficiency of a worm-driven back axle as a unit, a series of tests were made on a chassis which was in the course of erection. The cardon shaft was replaced by an Amsler torsional dynamometer, the differential was locked, the chassis jacked up, and a special pony brake was applied to one of the rear wheels. The resulting efficiencies at different speeds and loads varied from 94 per cent. to 96 per cent. The result included the loss in friction by the universal joint, journal and thrust races, felt washers, the air resistance of the spokes and felloes of the wheels, in fact as near as possible to the actual road conditions. When it is remarked that this worm and wheel had been assembled exactly as they came from the machine shop, it shows conclusively that, with the method and degree of accuracy obtained by the processes described, the high efficiency is attained right at the commencement, the net efficiency of this gear being within the region of 96 per cent. to 98 per cent.

Worm Gear Application.

Worm reducing gear units are with great advantage coupled direct to electric motors, enabling reductions in speed from 4 : 1 to 100 : 1 in a silent and efficient manner, and when both of them are mounted on the common baseplate they represent a simple, sound and economical proposition. For shop drives, machine tools, boiler feed pump, blower, and other work they have proved themselves to be invaluable.

On account of their ability to withstand considerable overload for short periods they lend themselves admirably to intermittent work, because for the work they are called upon to do they can be made relatively small; therefore they are of great use in crane work and for starting purposes of electric motors, steam, gas and oil engines.

In conclusion the author wishes to express his indebtedness to Messrs. David Brown and Sons for their kindness in placing at his disposal the facilities for the reading of this paper.

New Industries Established in the United Kingdom.—Since the outbreak of war many new industries have been established in the United Kingdom, and goods which formerly had to be obtained from abroad are now being manufactured at home. The Department of Commercial Intelligence (73, Basinghall-street, E.C. 2) desires to make its record of such new industries as complete as possible, in order to satisfy inquiries for new sources of supplies which are frequently received. Manufacturers are invited, therefore, to inform the department of new industries, or new developments of existing industries, established in this country.

COLONIAL ENGINEERING PROJECTS.

We give below a few data on several Colonial engineering projects taken from *The Board of Trade Journal*. Further information on these projects can be obtained from the Department of Commercial Intelligence, 73, Basinghall-street London, E.C 2:—

Canada.—The following notes of industrial activities in Canada, which would appear to afford openings for supplies of United Kingdom manufacture, are taken from a recent issue of *Canadian Machinery and Manufacturing News* (Toronto): A shipyard company at Three Rivers, Quebec, is buying equipment for a new plant to be erected there. There will probably be an opening for the installation of an auxiliary electrical power plant at Toronto in the near future. A copper company at Copper Cliff, Ontario, contemplates an extension of its plant, which will include the erection of a 3,000-ton mill. A company has been organised at Nelson, British Columbia, to supply electric light and power to that district. A hydro-electric system is to be adopted for the production of power at Picton, Ontario, and a similar system may be adopted at Thorold, Ontario. The possibilities of power development in the vicinity of Thessalon, Ontario, are being investigated. British firms interested may obtain the names of the companies concerned in the above-mentioned enterprises on application to the Department of Commercial Intelligence. In making application the reference number (375) should be quoted.

Australia.—In a former notice in *The Board of Trade Journal* respecting the Australian Budget for 1917–18 it was stated that a sum of 2,850,000*l* was to be advanced to the various States for the construction of silos for wheat storage. H.M. Trade Commissioner in Australia has now forwarded a copy of a Bill, which has been introduced into the Federal Parliament by the Premier of the Commonwealth, for the purpose of facilitating the construction of silos, in which it is proposed that a sum not exceeding the above amount may from time to time be advanced. The Bill also provides for the establishment of a Wheat Storage Commission. The Commission may (*a*) determine the design of silo to be adopted generally, or the particular design to be adopted in any particular place; (*b*) determine the number of silos to be erected, the places at which they are to be erected, the cost of each silo, and the cost per bushel to be charged for storing wheat therein; (*c*) arrange with the Governments of the respective States for the construction of silos by, or under the supervision of, the proper authorities of those States. It is reported in the Australian press that in introducing the Bill the Premier stated that it was proposed to provide silo storage for one-third—about 50,000,000 bushels—of the normal wheat crop of Australia. It appears that the Wheat Storage Commission has decided on various details of the storage scheme, and its conclusions were to be embodied in a report to the Federal Government. The present season's wheat crop in the Commonwealth is estimated to amount to, approximately, 135,000,000 bushels, and it is expected that exports will dispose of about one-third of that amount. The silos required for the portion of the crop which it is intended to store, will, it is proposed, form part of the general plan for the bulk-handling of wheat in the producing States. Temporary storage may be required for the remainder of the crop. The silos are to be erected at the wheat-shipping ports, in close proximity to the wharves, and will be built of concrete. The wheat, on arrival at the seaboard, will be stored in silos, and when required for export will be gravitated through pipes from the silos into the holds of the vessels being loaded. In this connection H.M. Trade Commissioner has notified that the Victorian Railway Department is inviting tenders for the preparation and supply of complete plans, working drawings, specifications, estimates, bills of material, &c., for systems of cylindrical reinforced concrete silos, with all necessary operating machinery and equipment, for wheat storage installations of various capacities at country railway stations and terminal points throughout the State. The proposed silos for which these particulars are required range from structures of 25,000 bushels capacity for country elevators, to structures with capacities of 420,000 bushels at Portland, 1,000,000 bushels at Geelong, and 2,200,000 bushels at Williamstown. The Victorian Minister of Railways, who is in charge of the State's wheat storage scheme, stated recently that a State Bill was to be introduced at an early date providing for the erection of 120 silos in Victoria, to accommodate about 10,500,000 bushels of wheat, 6,500,000 bushels of which would be stored at the seaboard and the balance in the country. The Commissioner is of opinion that there will not be much difficulty in securing supplies of cement of local manufacture for the construction of the silos required in the Commonwealth. On the other hand, however, stocks of reinforcing steel are stated to be below normal, and there may be a shortage of the steel required for the proposed storage silos.

Trade of New South Wales.—The oversea imports during June were valued at 1,988,026*l*., and show a decrease of 1,091,404*l*., or 35.4 per cent., as compared with the corresponding month of last year. The total for twelve months, July to June, 1916–17, was 32,740,566*l*., a decrease of 648,082*l*., or 1.9 per cent., in comparison with the figures for 1915–16. The oversea exports during June amounted to 3,534,126*l*., being an increase of 1,214,137*l*., or 52.3 per cent., as compared with the corresponding month of last year. For the twelve months, July to June, there was an increase of 1,170,172*l*., or over 2.8 per cent., compared with the same period for 1915–16.

CATALOGUES.

Steel Pile-Driving.—A good working assortment of technical data on pile-driving, sheet piling, materials and equipment has been printed in a waistcoat-pocket booklet issued by the British Steel Piling Company, Dock House, Billiter-street, E.C. 3.

Steel-Concrete Posts.—A system of making posts for railway signals, telegraphs, gates, fences, &c., is the subject of a catalogue issued by Messrs. John Ellis and Sons, Limited, 16, Pocklington's-walk, Leicester. It is patented and named the "Marriot System." The catalogue contains a number of illustrations of the finished products, all of which are hollow, with surfaces entirely concreted.

Time Recorder.—The Thames Manufacturing Company, Limited, Duke-street, London Bridge, send a catalogue showing the clock, recording mechanism and card cases which make up the apparatus manufactured by them for recording workmen's time "in" and "out" on cards. In this mechanism the time is printed or impressed, and not stamped by a hammer blow. Several patented improvements are added to the machines.

Lathe Grinding Machine.—Small machines for attachment to the tool post of an ordinary lathe are very useful for odd jobs and truing centres. The Light Electric Motor Company, 15, Baltic-street, Dundee, send catalogues of two such machines for external and one for internal grinding. All are for direct or alternating current, with speeds up to 3,500 r.p.m., and may be connected to an ordinary lighting circuit.

Electric Switch Gear.—The British Thomson-Houston Company, Limited, Rugby, has issued a catalogue dealing with their make of three-phase switch gear for mining and industrial use. These are designed on the draw-out principle, with oil break, totally enclosed, dust-proof and drip-proof. The various capacities required can be mounted side by side on a common form of pedestal and coupled to common bus-bars. Full details are given of capacity, dimensions, weights, packing, &c.

Thermometers.—A very full range of thermometers is shown in a catalogue received from the Cambridge Scientific Instrument Company, Limited, Cambridge. These are all of the dial type, and either indicating or recording. A Bourdon spiral with mercury is used to move the indicator or pencil; temperatures up to 540 deg. C. or 1,000 deg. F. are marked on the dials and graph discs; tubular extensions up to 75 ft. are supplied, and there are attachments for sounding an alarm at set limits of temperature, either high or low, or both. Two related temperatures, such as the water at inlet and outlet of an economiser, may be recorded on one paper.

Petrol Locomotives.—The Baldwin Locomotive Works Company, Philadelphia, send a catalogue describing a light locomotive which they are building in considerable numbers. There are five weights: in U.S.A. tons (100 lb. = 1 cwt.), 3½, 5, 7, 10 and 23. All except the largest have four wheels and four cylinders, the 23-ton engine having six of each. The fuel consumption is one-tenth of a gallon per horse-power per hour. The gearing gives two speeds of 4 miles to 5 miles and 8 miles to 10 miles per hour. The rail gauges of the standard engines are, in inches, 24, 30, 36 and 56½. The engine and transmission shaft are placed in the reverse of motor-car practice, the engine being at the back and the drive transmitted to a countershaft in front. The three-bevel reversing gear is used, and all gear wheels are always in mesh, the changes of speed and reverse being made by clutches. These engines look very serviceable. The return to simple direct mechanical methods of construction is conspicuous.

Uniflow Steam Engines.—In this type of engine the steam flows in a direct or continuous path, entering at the cylinder ends (as in the old type), but escaping when the pressure is exhausted at ports opening from mid-length of the cylinder. In this direction of flow itself there is an advantage, and there is a consequent, and perhaps equal, advantage in the hot pressure steam not coming so close to the cooled exhaust steam. While these advantages are obvious enough, and have long been well known to the reading engineer, they have only of late years been realised into working mechanical form. Messrs. Robey and Co., of Lincoln, and 91, Queen Victoria-street, E.C. 4, who have made a special study of the construction of this engine, and have a large number in operation, send us a catalogue showing full details and explaining the cylinder, valves, valve gear, governing and other principal parts. In its improved form the engine is very simple and compact, both as to floor space and headroom, with all the parts easily accessible. Diagrams show that the steam is economically used, the loss area being less in a single-cylinder uniflow than in a quadruple-expansion engine. With this goes a greatly decreased cost of construction, maintenance of wearing parts and of working space. The engine may be made condensing or non-condensing, and is suitable for the highest pressures and superheat. Eighteen sizes are listed as standard, from 60 i.h.p. to 1,000 i.h.p. These are the economical running powers, and the engines will develop a maximum continuous running power of from about 33 per cent. in the smaller to 25 per cent. in the larger sizes. The revolutions per minute are from 200 in the smaller to 120 in the larger engines. The total weight of the engines is from 3 cwt. per horse-power in the smallest to 1.28 cwt. per horse-power in the largest, taking the maximum powers. The illustrations show the engine applied to mill driving, generator driving and winding. Many sectional and part illustrations are also given.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AGRICULTURAL APPLIANCES.

108,584. F. M. Waller, Stafford, Staffordshire. Mechanical Tractors. (2 *Figs.*) October 11, 1916.—This invention relates to mechanical tractors for agricultural purposes of the purely tractor type, and particularly to tractors of the type having only three wheels, two of which are driving wheels and the third of which is a balancing or supporting wheel. A tractor constructed according to the present invention comprises a main frame *a* supported by two driving wheels *b*, *b*; a secondary frame *c* pivoted to the main frame *a* to the rear of the axis of the driving wheels *b*, and carrying a wheel *f* carried in a fork *e* capable of being locked in position in the head *d*, and mechanism for setting up relative movement between the main and the secondary frames for steering purposes. A convenient mechanism for setting up relative movement between the two frames comprises a spindle *h* mounted in a column *k*

Fig. 1.

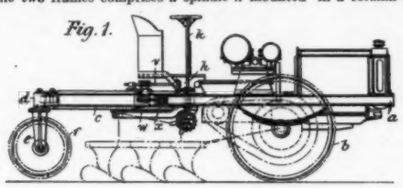
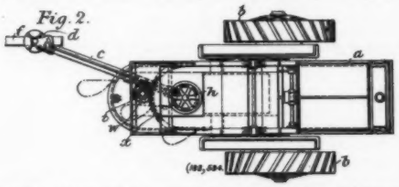


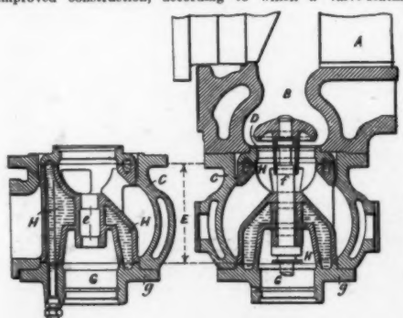
Fig. 2.



carrying a hand wheel mounted in juxtaposition to the driver's seat, a semicircular rack *x* carried by the main frame *a*, a spindle *t* mounted on the secondary frame, a pinion *w* fixed on said spindle, a shaft *v* running between the spindle *h* and the spindle *t*, bevel gearing connecting the spindle *h* to the shaft *v*, and worm gearing connecting the shaft *v* to the spindle *t*. It will be seen that the tractor is virtually steered and guided by the driving wheels, and consequently there is little, if any, tendency for the machine to slip sideways when working on sloping ground, and that any such tendency can at once be corrected and controlled by the steersman. Further, that owing to the offset position of the rear wheel it runs on unploughed land, so that its movements are therefore less trammelled than they would be if it were running on the newly-turned furrows. (*Accepted August* 22, 1917.)

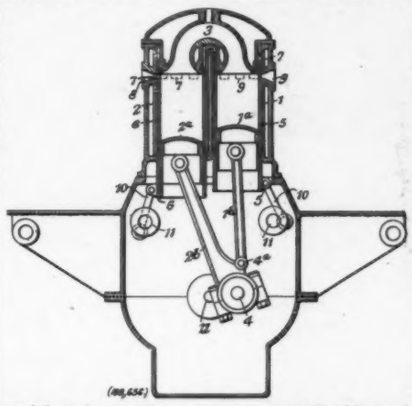
GAS ENGINES, PRODUCERS, HOLDERS, &c.

108,594. H. Crowe, Saltburn-by-the-Sea, Yorkshire. Valves. (2 *Figs.*) October 28, 1916.—This invention relates to renewable fluid-cooled valve seatings of internal-combustion engines, which seatings are of the type wherein they are formed separately from and fitted to valve boxes or casings which may themselves be fluid-cooled, and which casings are connected directly with the pipes or ducts employed for the passage of the fluid or gas passing through the valves. It consists in an improved construction, according to which a valve-seating



casting is constructed in two or more sections having suitable joints between them, thus permitting of the speedy dismantling or assembling of the valve, and affording ready access to the internal cooling chamber for cleaning, or for the replacement of a cracked or damaged section, the joint or joints of the seating being made in any position or plane which may be found most desirable according to the general shape or arrangement of the whole seating. According to the invention, the exhaust port B connecting the cylinder A of the engine with the valve may be of any convenient construction, and the valve casing C may also be of any ordinary construction, as shown, with or without a water jacket. The valve seating is, in the construction shown, made in three pieces, the actual valve seating D, the main central part E, with the guide *e* for the valve spindle *f*, and the outer end part G. These parts are made with passages or recesses which, when the parts are assembled, register to form a water chamber H. The parts may be held together by bolts passed through the separate parts, but the arrangement shown in the drawing is the best and simplest for the purpose. According to this arrangement the parts D and E are held in position simply by the pressure of the part G upon them, this latter part being bolted or screwed to the valve casing C by means of the flange *g*. In this arrangement, when the part G is unbolted or unscrewed the other parts come away separately without any difficulty. (*Accepted August* 22, 1917.)

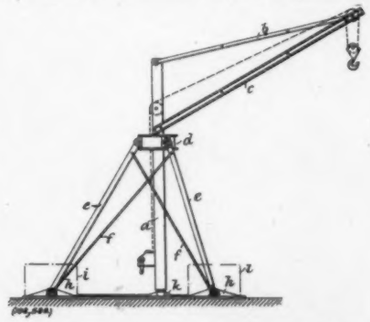
108,656. T. A. N. Leadbetter, Hale, Cheshire, A. L. K. Gilchrist, Lytham, Lancashire, and W. H. Tate, Ashton-on-Mersey. Internal-Combustion Engines. (2 *Figs.*) April 27, 1917.—This invention relates to internal combustion engines acting on the Otto cycle. According to this invention, each engine unit comprises twin cylinders, 1, 2, communicating at the top or head in an explosion chamber 3 common to both cylinders. The inlet and exhaust of the gases is controlled by means of sleeve valves 5, 6 mounted between the pistons 1*a*, 2*a* and the cylinders and operated either by a reciprocating or rotary movement, such movement being effected by means of links and disc cranks, chains or eccentrics, from auxiliary shafts 11 driven from the crankshaft. The twin pistons of each unit are



coupled up to a crank-pin 4, common to both pistons. As illustrated, the twin cylinders 1, 2 open into a common combustion chamber 3, the pistons 1*a*, 2*a* being connected respectively by rods 1*b*, 2*b* to the crank-pin 4 and a knuckle 4*a* on the connecting rod 2*b* of the other piston. The inlet and exhaust for the fuel charge and spent gas into and from the combustion chamber 3 are controlled by sleeves 5, 6 sliding in the cylinders 1, 2, the pistons 1*a*, 2*a* reciprocating within the sleeves. Ports 7 in each sleeve are adapted, as the latter reciprocate, to uncover the inlet and exhaust ports 8, 9, and thus control the fuel charge and exhaust gases. The sleeves are reciprocated by links 10, driven from auxiliary shafts 11, operated in any suitable manner from the main crankshaft 12, the movement of the sleeves being timed as required. (*Accepted August* 22, 1917.)

LIFTING AND HAULING APPLIANCES.

108,580. Herbert Morris, Limited, and J. Shelley, Loughborough, Leicestershire. Jib Cranes. (4 *Figs.*) October 6, 1916.—The invention relates to that class of jib crane in which the component members are intentionally made capable of easy detachment from and attachment to each other for the purpose of facilitating transport to and erection at any required place. The jib is mounted on a vertical post *a*, and consists of the tension member *b* and the compression member *c*. Below the point of attachment of the jib to the post a bearing is



formed on the post and journalled in a horizontal ring *d*, which is supported by inclined legs *e* extending to the ground. To prevent the ring *d* rocking out of the horizontal, guy ropes *f* are attached to the base of each leg *e* and taken to the heads of the next adjacent legs. The lower ends of the legs *e* have baseplates *h*, which may carry boxes *i* for holding ballast to prevent the crane tipping, or may be spiked into sleepers or into the ground, either by separate loose spikes or spikes formed integral with the baseplates. The central footstep bearing *k* for the crane post may be centralised by ties from the baseplates *h*, or be spiked into the ground to centralise it. (*Accepted August* 22, 1917.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

101,340. Pratt and Whitney Company, New York, U.S.A. Self-Centering Chucks. (3 *Figs.*) August 28, 1915.—This invention relates to self-centering chucks of the class having a main supporting member furnished with a lateral passage communicating with the central bore through which work-pieces may be inserted and removed, and with work-holding jaws mounted so as to be simultaneously adjusted with respect to each other and the work-piece. According to this invention the chuck consists of a main supporting member and three symmetrically radially disposed gripping jaws, two of such jaws being connected to a third jaw by racks and pinions, so that when the third jaw is moved longitudinally by means of gearing a corresponding movement is imparted to the other two jaws. Each of the chucks is provided with a central bore 17 and a lateral opening 18 communicating with the bore and through which work-pieces may be laterally inserted or removed. The clamping jaws 7, 8 and 9 are disposed symmetrically and radially about the bore 17, and are slidably mounted in the chucks. These jaws, however, are adapted for simultaneous

Fig. 1.

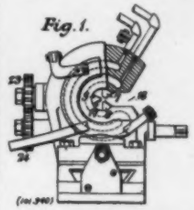
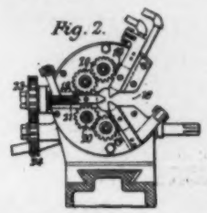


Fig. 2.



adjustment by interconnections indicated as comprising rack teeth 19 and intermeshing pinions 20. One of the jaws, for example 9, is also provided with an internal threading 21 which receives a threaded stub shaft 22 rotatable by a pinion 23 intermeshing with a driving gear 24 operated from a suitable source. It will be noted that the construction described is such that rotation of shaft 22 in one direction effects a withdrawal of clamping jaw 9, and through the intermeshing racks and pinions a simultaneous and coequal withdrawal of the jaws 7 and 8. Similarly, operation of shaft 22 in the reverse direction effects simultaneous adjustment of the centering jaws inward to grip a work-piece. (*Accepted August* 22, 1917.)

108,561. Alfred Partridge and Co., Limited, Stockport, Cheshire, and J. H. Bradshaw, Heaviley, Stockport, Cheshire. Lathe Chucks. (6 *Figs.*) September 6, 1916.—This invention relates to that type of lathe chucks the body of which contains a number of oscillatable grippers under the control of a spring-influenced member rotatable on the chuck body, and which have each a round back adapted to bear against a semi-circular cavity, and at the rear end a pivot adapted to engage in a groove in the body of the chuck. The invention consists in forming not only the rear end of the said gripper with a pivot, but also the front end thereof adapted to engage in a hole formed in a plate secured to the front end of the chuck. According to one embodiment of the invention, when constructing a lathe chuck having three grippers for holding small work, such as cylindrical studs, a corresponding number of cavities *a*, having each a semicircular top, are formed in the free end of the bore of the chuck, equal distances apart, and a gripper *c* is oscillatably mounted in each of the said cavities. Each gripper *c* is formed partly cylindrical to fit the cavity *a*, and has a single cam or eccentric surface and, at the outer end, an arm *e*. The ends of

Fig. 1.

Fig. 2.

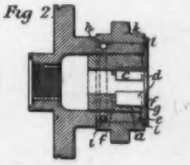
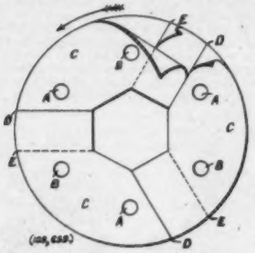


Fig. 3.

the said grippers have each a pivot *f*, which pivots engage in holes formed in the chuck and serve to support the gripper, while the said semicircular cavity receives the thrust of the gripper when forced against it. Between two shoulders *h*, *i* on the periphery of the chuck a ring *k* is seated, placed under the influence of a spring *l*, Figs. 1 and 3, which tends to turn it in the direction in which the chuck rotates. The outer side of the ring *k* has slots *m*, in which engage the free ends of the gripper arms *e*. When slightly turning the ring *k* in a direction opposite to that in which the chuck rotates, by holding it with the hand, it will oscillate the grippers and cause their cam or eccentric surfaces to recede from the bore of the chuck, and thereby open it and release the work therein, whilst when the hold on the ring *k* is released the spring *l* will cause the ring *k* to turn back and oscillate the grippers *c* in the reverse direction, so that the cam or eccentric surfaces *d* will be projected, and thereby the work held in the chuck. The inner shoulder *h* may be formed on the chuck itself, and the outer one by a plate *i* secured to the end of the chuck as may be found most suitable. (*Accepted August* 22, 1917.)

108,659. E. J. Hardy and Ed. J. Hardy and Co., Limited, Coventry, Warwickshire. Universal Joints. (1 *Fig.*) May 10, 1917.—This invention relates to flexible universal joints of the kind in which a driven shaft element and a driving shaft element are provided at their adjacent ends with jaws or studs arranged so that the driving studs and the driven studs are alternately disposed in one plane; a disc or ring composed of adhering layers of textile fabric, provided with suitable holes, being slipped on to the studs to transmit the drive. According to this invention, each layer of textile fabric is formed in similarly-shaped segments, each of which segments transmits the driving pull from a driving stud to its adjacent driven stud, and all the segments are cut from the fabric so that the threads are parallel to a line joining the said studs, and the joints of segments in adjacent layers are staggered. The drawing shows a ring suitable for a three-point universal joint. The holes A can receive the three studs of the driving element and the holes B can receive the three studs of the driven element. The direction of rotation is indicated by the arrow. Each of the three segments C forming a layer are similarly shaped in all the layers, which simplifies their manufacture. They are cut from the fabric so that the threads run parallel to a line joining the holes A and B in each segment, so that there is always a straight pull on the threads on the material. Any number of layers may be used in the manufacture of a ring, and they are secured

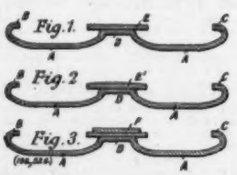
together by vulcanisation or other suitable means. It will be seen that the joints in the segments are not subjected to transmission stresses when the direction of rotation is that shown



by the arrow. The lines D and E indicate staggered joints of the segments throughout the thickness of the ring. (*Accepted August* 22, 1917.)

MOTOR ROAD VEHICLES.

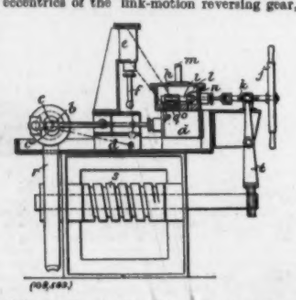
108,526. The Dunlop Rubber Company, Limited, Westminster, London, and F. J. Keegan, Coventry, Warwickshire. Vehicle Wheels. (6 *Figs.*) August 9, 1916.—This invention relates to vehicle wheels of the kind which are provided with twin tyres. According to this invention, the rim, which, as before, is of sufficient width to receive two tyres, is provided with a member or members upon a raised or outwardly bulged middle portion of the rim for retaining the inner or adjacent edges of the two tyres in position. A represents a rim of sufficient width to accommodate two tyres, and B, C indicate the tyre-retaining flanges at the edges of the rim A. In the example shown in Figs. 1 to 3 the rim is raised or outwardly bulged at the centre or middle part D to form a circumferential



spacing or distance-member between the two tyres (not shown). A flat, retaining annular member, or ring E, of greater width than the portion D, is mounted or secured on the said raised annular part D of the rim in any appropriate manner, so that its edges project beyond the part D in order to form annular flanges or lips for holding or retaining the inner edges of the tyres in position. The ring E, as shown in Fig. 1, is of true rectangular section, but in some cases it may be strengthened by making the outer surface E^1 thereof slightly curved or convex in a transverse direction (see Fig. 2), or as shown in Fig. 3, two (or more, if desired) concentric rings E, F may be positioned and secured, one within the other, on the raised part D, the inner ring E being wider than the outer ring F. (*Accepted August* 22, 1917.)

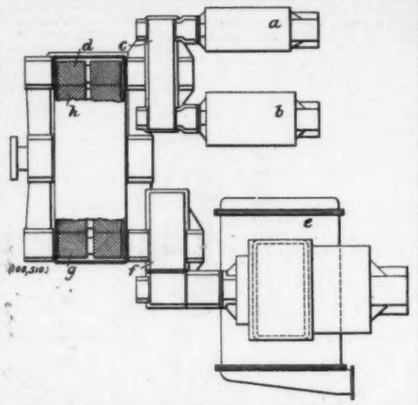
SHIPS AND NAUTICAL APPLIANCES, &c.

108,583. D. Donald and L. McL. Donald, East Dulwich, London. Steering Engines. (1 *Fig.*) October 10, 1916.—This improvement relates to the valve mechanism of engines for actuating steering gears in which the motive power is steam, and to which a differential or hunting motion is applied, so that the engines follow exactly the movements of the hand wheel actuated by the steersman, and start, stop and reverse in accordance therewith. According to this invention the reversing gears are moved from the extreme position for the engines running in one direction to the extreme position for the engines running in the contrary direction, and *vice versâ*, by steam acting through the medium of a cylinder with its piston and rod coupled up to the reversing gears. The steam to actuate the piston is controlled by a D slide valve actuated by the steering wheel. In conjunction with this valve, and moving with it, is a valve controlling the admission of steam to the engines; *a* is one cylinder of the steering engine; *b* is the crankshaft; *c*, *c*^{1} the eccentrics of the link-motion reversing gear, and *d* is



the link giving motion to the slide valve (not shown) of the cylinder *a* in the usual manner. The cylinder *e*, acting through its piston and rod, is connected to the link *d*. The action of the cylinder *e* is controlled by the controlling valve A, which is mounted on the spindle *i* operated by the steering wheel *j* through the screw *k*. The controlling valve A is placed in the chest *l*, to which steam is conveyed by the pipe *m*. A valve *n* is also mounted on the spindle *i*, and controls the supply of steam to the slide valve chest of the cylinder *a*. The controlling valve A covers ports *o* and *p* connected, respectively, to the top and bottom of the cylinder *e*. The centre port *q* is the exhaust. The crankshaft *b* drives through a worm and worm wheel *r* the barrel *s*, to which is attached the chains for actuating the rudder; *t* is the hunting gear. By manipulating the steering wheel *j* in either direction the control valve A is moved and admits steam to either end of the cylinder *e*, and the link *d* is put to its extreme position in either direction. At the same time the valve *n* is moved and admits steam to the slide-valve chest of the cylinder *a*, the crankshaft revolves accordingly, and movement is given to the rudder in the desired direction. The hunting gear *t* brings back the controlling valve *h* and the valve *n* to cover their ports, steam is cut off from the engine and it stops at the position corresponding to the movement given to the steering wheel *j*. (*Accepted August* 22, 1917.)

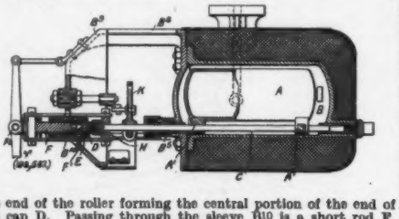
108,510. The Hon. Sir C. A. Parsons, Newcastle-on-Tyne. Ship Propulsion. (2 *Figs.*) August 4, 1916.—The invention consists in a geared turbine installation for ship propulsion of the type comprising three turbines connected in series for steam flow, and operating the propeller shaft through double-reduction gearing, all the turbines being provided with blading of the reaction type and being constructed without balancing pistons, the high and intermediate pressure turbine pinions being arranged to operate a common gear wheel, while the low-pressure turbine pinion operates another gear wheel, each of these gear wheels operating separate co-axial pinions engaging with a main gear wheel mounted on the propeller



shaft, the high-pressure turbine having the highest rate of revolution and the low-pressure turbine having the lowest rate of revolution, while the high and intermediate-pressure turbines each develop substantially one-quarter of the total power. The high-pressure turbine *a* and the intermediate turbine *b* drive pinions which are geared to a common gear wheel in the casing *c* driving the pinions *d*. The low-pressure turbine *e* drives a gear wheel in the casing *f* on the shaft carrying the pinion *g*. The pinions *d* and *g* drive the common gear wheel *h* mounted on the propeller shaft. The steam flow is through the turbines *a*, *b* and *c* in series. Each of the turbines *a* and *b* provides substantially a quarter of the power, while the turbine *c* provides one-half of the power. (*Accepted August* 22, 1917.)

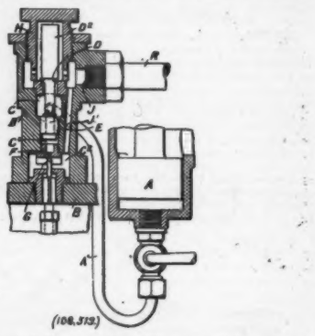
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

108,507. T. Clarkson, Chelmsford, Essex. Steam Generators. (2 *Figs.*) August 4, 1916.—This invention relates to feed-water supply apparatus for steam generators, and has particular reference to float-controlled apparatus. According to this invention, the spindle of the float is operated by a rod or plunger in axial alignment with the float spindle, the adjacent ends of the spindle and the rod being formed of hardened surfaces, one preferably plane and the other convex, the two hardened surfaces being in contact. The float A is contained in a float chamber B, mounted with its axis horizontal, so positioned that the normal water-level in the steam generator will correspond approximately to the axis of the float chamber. Near each end of the float A lugs A^1 are welded, and a spindle C passes through, and is secured in, these lugs. One end of the spindle C projects through a stuffing-box B^9 formed on the cover of the float chamber. The cover of the float chamber is provided with angle arms B^1, which support a circular shield B^2 formed with a sleeve B^{10}, in axial alignment with the spindle C. The end of the spindle C is screwed and furnished with a cap D of sufficient length to extend into the sleeve B^{10}, and its end is drilled centrally to accommodate a hardened steel roller E, the



flat end of the roller forming the central portion of the end of the cap D. Passing through the sleeve B^{10} is a short rod F, having at its inner end a hardened steel ball F^1, which bears against the centre of the flat end of the roller E. At the other end of the rod F is an eye F^2, connected to a lever G^1 which, at its upper extremity, is pivoted on the shield B^2. The other end of this lever G^1 is connected to some member which will give it a slow reciprocating movement. Fitting loosely round the spindle C is a sleeve H, connected by links H^1 to the rod F. When the lever G^1 is moved inwards the ball F^1 presses against the roller E and causes the spindle C and float A to move longitudinally relatively to the float chamber B, and when the lever G^1 is moved in the opposite direction the links H^1, acting through the sleeve H, pull that spindle and the float back into their original position. This motion, which is slow and continuous, ensures that the float shall keep sensitive, so that it may rise and fall with any difference in the level of the water in the float chamber, and in thus rising and falling rotary motion is imparted to the float spindle C. Upon the float spindle C is mounted the arm K, which may serve as an indicator, and can also be used through any suitable mechanism to control the supply of water to the steam generator. (*Accepted August* 22, 1917.)

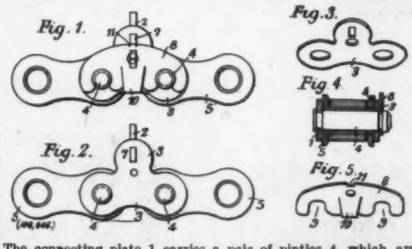
108,513. A. H. Anthony, Colchester, Essex. Automatic Feed Regulators. (3 *Figs.*) August 5, 1916.—This invention relates to automatic feed regulators for boilers of the kind in which the feed check-valve to the boiler is provided with a balancing piston, moving in the closed end of a cylinder, and the water which leaks past the piston into the end of the cylinder escapes from the cylinder under the control of a valve automatically regulated by a float, the float being arranged at the water-level of the boiler. The present invention provides the combination with the float valve and feed-check valve, in an automatic feed regulator of the kind above defined, of a control piston for the feed-check valve, into whose cylinder fluid is made to leak at a rate less than that occurring past an ordinary balancing piston for the feed-check valve having the same diameter as that valve, and an escape for the said fluid from the said cylinder controlled by the float valve, so that the float valve controls the feed-check valve through the said control piston. A is the feed-check valve housing containing that valve and its ordinary balancing piston, which is of the same diameter as that valve. B is the ordinary float chamber at the water-level of the boiler. The leak-water is brought by a pipe A^1 into a chamber C in a casing B^1, arranged above the float chamber. The chamber C is closed by a valve D provided with a balancing piston E, which latter constitutes a control piston through the medium of which the float valve controls the feed-check valve. The piston E works in a cylinder, from the closed end of which the only escape is by way of port F, controlled by the float valve G, which is a needle valve. The piston E is made of slightly larger diameter than the seating of the valve D, so as to constitute a small load upon the valve. The valve D is seated



in a removable seating held in place by a recessed screw-plug H, into whose recess extends an extension D^2 of the valve body, to provide convenient means for lifting the valve and its piston out of their housing, together with the valve seating. The outlet from the chamber C is by way of the valve D and an escape duct J, which last communicates by a pipe R with a drain. The port F opens into a chamber C^2 formed between the top of the float chamber and the underside of the float-valve seating, and a duct J^1 gives free escape from the chamber C^2. The operation of the apparatus is as follows: When the feed-water is entering the boiler, the leak-water, coming from the balancing piston in the casing A, by way of the pipe A^1, will normally hold the valve D down upon its seating, owing to the loading effect of the control piston E. The pressure of the leak-water in the chamber C will eventually become equal to that of the feed-water in the casing A. Leakage occurs past the piston E into the chamber C^1, and so long as the water-level in the boiler needs to be raised, the valve G remains open and the leakage past the piston E escapes freely by the duct J^1 to the outlet J. When, however, the water-level in the boiler has reached the desired height, the valve G is closed; with the result that the balance of the piston E is destroyed and the leakage from A lifts the valve D and escapes at J. This allows the feed-check valve to close upon its seating, and stops the feed. (*Accepted August* 22, 1917.)

MISCELLANEOUS.

108,646. H. S. Yoxall and G. Wadhams, Birmingham, Warwickshire. Driving Chains. (8 *Figs.*) March 6, 1917.—This invention has reference to driving chains, and comprises an improved means for detachably uniting the ends of such chains of the kind in which one of the connecting plates is detachable from its two pintles, one end of which is provided with an annular groove adapted to receive a sheet-metal locking plate upon the outside of the connecting plate, and to thereby prevent the connecting plate from being accidentally removed from the pintles, and wherein the locking plate is provided with a spring tongue-piece adapted to engage with the connecting plate for the purpose of retaining it in position. According to this invention, in means of the type specified for detachably securing the ends of a driving chain together, having a plate pressed from sheet metal adapted to engage annular grooves upon the pintles, the applicants employ a spring tongue pressed out to engage with the connecting plate and a notch adapted to engage with an external projection upon the connecting plate.



The connecting plate 1 carries a pair of pintles 4, which are firmly secured to the said plate, and which serve to unite the two ordinary links 5 of the chain, these rivets each having an annular groove near their free ends. The loose connecting plate 3 is adapted to slip over the free ends of the pintles, and also over the projection 7 of the bridge-piece 2, the connecting plates serving to take the tensional load of the chain, the plate 3 being, however, secured in place by means of the locking plate 8, which is formed from thin spring steel cut away at 9 to engage with the annular grooves of the pintles, and when this locking plate is in position it will be obvious that the loose connecting plate cannot be detached from the rivets. To secure the locking plate in position it is provided with a spring tongue-piece 10, the extremity of which engages with the lower edge of the connecting plate, and is also provided with a notch or pressed-back part 11, which engages with the extremity of the part 7, the combined effect of these two engagements serving to prevent detachment of the locking plate. As a further security, however, a cotter-pin may be provided. (*Accepted August* 22, 1917.)